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AUTHOR Griffiths, Jose-Marie
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ABSTRACT

This study assesses the application of both minicomputers and microcomputers to information-handling procedures and makes recommendations for automating such procedures, particularly in developing nations. The report is based on a survey of existing uses of small computing equipment in libraries, archives, and information centers which was conducted from October 1979 to May 1980. Following a description of report aims and layout, a discussion of the impact of computer technology on information handling traces the history of the relationship between computers and information systems and outlines historical changes that have occurred in computer technology. Examples given of small-scale computing equipment usage in information handling deal primarily with microcomputers and include unusual projects. Other chapters clarify terminology and formulate definitions, identify basic components of minicomputer systems in terms of equipment selection criteria, discuss current trends in information systems and services development, and predict changes which will affect information handling. The effect of these changes on information professionals and educators is considered, and recommendations are made for further investigations, education and training requirements, and standards for systems and documentation. Report annexes provide background detail and deal with terminology, minicomputer manufacturers, and microcomputer systems. (Author/LMM)

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Paris, November 1981

APPLICATION OF MINICOMPUTERS AND MICROCOMPUTERS TO INFORMATION HANDLING

prepared by

José-Marie Griffiths

General Information Programme and Unisist

United Nations Educational,
Scientific and Cultural Organization

IR050 112

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PREFACE

This study was foreseen in the work plan of Unesco for 1979-1980 (20 C/5, §5162) to provide an overview of the present and future possibilities for using mini- and microcomputers in information handling and to assist readers in deciding on the acquisition of small-scale computer equipment and related software for libraries and information centres. It has been written especially for policy-makers, planners and specialists in the information field, who may have only basic notions in the area of computer science; it should also be a useful teaching and learning aid in educational programmes in information science. It is hoped that the study will be particularly relevant to the needs of the developing countries.

The study has been prepared for Unesco under contract by Mrs. José-Marie Griffiths, presently Senior Research Associate at King Research Inc. (Rockville, Maryland, USA), partially on the basis of an inquiry on the use of mini- and microcomputers which Unesco conducted among national information focal points and UNISIST National Committees. Annexes II and III, giving names of computer manufacturers, are based on the experience of the author and are necessarily incomplete in this version of the study. In addition, it is realized that the cited examples of computer applications in Member States cannot be considered to be truly representative of international efforts in this field in this initial Unesco study. The opinions expressed herein are those of the author and do not necessarily reflect those of Unesco.

This work falls within the efforts of the Unesco General Information Programme to promote international exchange of experience on questions of information-handling technology, and to facilitate appropriate use of such technology in Member States. Suggestions, evaluative comments and information on further developments in the area of mini- and microcomputers are very much welcomed from the readers; it is especially hoped that additional examples of available hardware and of software developments in the world will be provided so that the coverage of study can be appropriately updated and extended in the future. Comments should be addressed to the Division of the General Information Programme, Unesco, 7 Place de Fontenoy, 75700 Paris.

A companion study entitled "The Use of Satellite Communication for Information Transfer" has been commissioned concurrently with the present work and can also be obtained at the above address.

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EXECUTIVE SUMMARY

Aims of the study

The general aim of this study is to assess the application of both minicomputers and microcomputers to information handling procedures and to make recommendations on a methodology for automating such procedures, particularly to the developing nations. The boundary between mini/microcomputers and mainframe computers is somewhat subject to interpretation and, for the purpose of this study, minicomputers are defined as small general purpose computers which operate in a variety of applications. A microcomputer is a minicomputer which has a microprocessor-based CPU. The term "information handling" is also very broad and in this study has been restricted to apply to the handling of organised collections of recorded information of the type traditionally available in libraries, archives and information and reference services.

A survey of existing uses of mini and micro computers in libraries, archives and information services was conducted over an eight month period. It soon became obvious that most preparatory procedures for dissemination of information e.g. preparation of a database in machine-readable form, typesetting for publication etc., involved the use of small-scale computing equipment at some stage in the process. The survey, therefore, does not claim to be comprehensive and examples quoted in this study have been selected to highlight the more specialised functions of mini and micro computers in information handling.

The recent increase of personal computers on the market has resulted in many specialised applications of such machines in information handling. Unfortunately, much of this work remains undocumented. A secondary aim of the study is to collect details of work completed and in progress that might usefully be exploited by others, and so avoid needless duplication and encourage standardisation.

The impact of computer technology on information handling

Computers were first applied to information handling in the early 1960's for the production of abstracting and indexing journals. Once in machine-readable form it was a natural extension to make the files of bibliographic information available for searching, first in batch mode and eventually in interactive mode. Since then, the database services have been considerably enhanced to become the systems we know today.

A number of technological advances have enriched the information handling power of systems, of which the most dramatic has been the development of timesharing systems. These enable many

users to access an information bank simultaneously, each user being virtually unaware of the other users of the system.

The reduction in size and cost of magnetic memory has meant that considerably more information can be made available to the user at any one time. This trend is still continuing with the development of bubble memories and videodisks for primary and secondary storage.

Telecommunications technology has progressed to facilitate the interconnection of systems so that databases need not be physically located at one place but can be distributed around a network. This development had initiated and sustained the effort to standardise the interfaces between systems, although further work is still required in this area.

Teletext and Videotex are recent entrants to the information scene. Although teletext and Videotex terminals are generally not computers in the strict sense, these systems are discussed in the present study because of their conceptual and technological similarities with computer communication networks, and their great potential importance in information handling. Teletext is a continuous stream of information broadcast over the air and received by an adapted domestic television set. Videotex is an information system accessed via the telephone network using a keypad and displayed on an adapted television receiver. Both systems have significantly extended the range of information available to the public from their own homes.

One major impact of these technological developments on information handling has been the shift of concern from volume of information available to the quality of that information. As more information is readily available to us in machine-readable form we are concerned about its accuracy, currency (timeliness) and integrity.

A second impact of the developments is the change in training requirements. As computers are used increasingly for provision of information, librarians and other information professionals must familiarise themselves with the latest technologies.

Applications of minis and micros to information handling

Traditional applications of computers to information handling have used large mainframes to store vast quantities of data e.g. the large database services, on-line library catalagues. Smaller libraries have grouped together to form co-operatives in order to make efficient use of these large, expensive machines.

With the reduction in circuit sizes and memory sizes a reasonable portion of work done by large computers could successfully be transferred to minis which are cheaper to run and

do not require such carefully controlled environmental conditions. However, it is unlikely, for a long time to come, that such applications could run on microcomputers. Instead, small-scale computing machinery can be used to perform a number of specific information handling tasks which previously did not justify the acquisition of costly computing equipment. These tasks can be divided into four main categories:

(i) small in-house databases

Microcomputers are particularly useful for storing localised information that needs frequent updating. Examples are local events listings at the reference desk in a library, details of work schedules, loan transactions for small libraries etc.

(ii) pre-processors

A certain amount of prior local processing can reduce the time and cost of accessing larger systems particularly when telecommunications costs are high. For example, prior to an on-line search performed on several databases, a small computer can be used to store previous search strategies, remind the user of the command language and syntax of particular systems, automatically perform all logging-in procedures from a pre-programmed key and so on.

(iii) post-processors

After contact with another system, a small computer can select out just the information required, can reorganise it into a desired local format, substitute local features such as codes or preferred names, eliminate duplicate information and generally output the information for particular sets of users. For example, a medical information systems could output the Latin term "rubella" for doctors and specialists, and the term "German measles" for lay persons using the system.

(iv) education and training

One of the greatest potential uses of small-scale computing equipment is in the education and training of library and information professionals. There has been a recent burst of activity to develop self-paced computer-aided-instruction (CAI) packages for this purpose. Through simulations and computer models trainees can familiarise themselves with particular systems without incurring the costs of using the real systems. Once their confidence has been established they can transfer to the actual systems.

Minicomputers and microcomputers

Minicomputers, introduced during the early 1960's were initially developed as low-cost digital computers with a minimum

of processing power, memory and software support. However, it was soon recognised that minis had a potential use in a number of unrelated areas and that they should be adaptable to the requirements of each.

The advances in basic integrated circuit fabrication technologies had an immediate impact on minicomputers by continually reducing their cost and size and by improving their computational power and reliability. The impact of the microprocessor, where a complete CPU is placed on a single chip which can then be used to build computers, is being felt at the lower end of the minicomputer range. Very low cost, yet relatively powerful, micros are finding new application areas where minis were considered too bulky and expensive.

Two significant developments in mini/micro computer technology have encouraged their use for information handling. They are increase in word size and the availablility of high level programming languages. The increase in word length has meant that more data can be moved around the system at any one time resulting in faster and more efficient processing. When microcomputers first appeared on the market they had to be programmed in machine code and assembler language. The instruction sets were unique to particular families of microprocessors. By the mid-1970's BASIC had become a commonly available language on micros and by the late 1970's FORTRAN, COBOL, PASCAL and PL/1 were also available. Operating systems have become more sophisticated making micros easier to use.

Such developments have reduced the training requirement in terms of complexity and have made software considerably more portable. This trend is reflected in the number of software packages available for specific applications.

Future trends

In the immediate future the current trends of reduction in size and cost for increase in power, reliability and flexibility will continue. Similarly, developments in software will continue to make systems easier to use. Viewdata-type systems will become more common and should begin to include retrieval features such as cross-referencing.

The mode of interaction with computers is likely to become more flexible with the introduction of voice recognition, speech synthesis and touch sensitive machines and research is continuing to improve the user/system interface.

Overall, the trend will be for greater variety of information systems to be interconnected whilst at the same time becoming more "user friendly". One potential concern that is likely to arise is the problem of information overload; a problem which returns us to the idea of quality filters or quality assessments.

Conclusion

Recommendations are made at two levels: national and institutional (or organisational). At the national level the areas addressed are:

- further investigations
- education
- standards.

At the level of the individual institution or organisation the following areas of limitations of microcomputers are discussed:

- storage
- timesharing
- operating environment
- interfacing with other systems
- upgrading
- servicing
- software
- training.

It would seem that the potential for using small-scale computers for information handling is enormous although the use of technologically advanced equipment will not necessarily solve the problems of organisation and retrieval of information.

CHAPTER I

INTRODUCTION

Aims of the study

The general aim of this study is to provide an up-to-date assessment of the application of minicomputers and microcomputers to information handling and to make recommendations, to the developing nations in particular, on the use of small-scale computing equipment in automating information handling procedures.

In recent years there has been a vast increase in the numbers and types of small-scale computers available to the consumer, making selection more difficult. The overall trend in the development of small-scale systems has been a substantial reduction in cost, physical size and environmental requirements for operation. At the same time, the systems have an increased reliability and manufacturers have improved both hardware and software support.

Traditionally, the majority of automated information handling operations have been supported on large, centralised mainframe computers. It has only been over the last few years that minicomputers, or, more precisely, networks of interlinked minicomputers have emerged as an alternative proposition. Now, the low cost microcomputer brings automation within reach of most small organisations. This report aims to make the reader aware of the ongoing development in the computer industry and of those information handling processes that are most likely to benefit from the new technologies.

Report layout

A survey of existing microcomputer applications in information handling was conducted over an eight month period from October 1979 to May 1980. In order to supplement the independent investigation of the author, a circular letter was sent by Unesco in November 1979 to UNISIST National Committees and national

information focal points in Member States soliciting contributions on national experiences in this area. As this report was being compiled, data were still being received and several new microcomputers were announced. The rapid change in market availability of new machines is such that this report is destined to be out-of-date even before it is published.

Chapter II of the report discusses the impact of computer technology on information handling. It traces the history of the relationship between computers and information systems and outlines the changes that have occurred in computer technology, from the production of the first computer to the present day machines.

Chapter III attempts to clarify terminology and formulate definitions. The basic components of minicomputer systems are identified and discussed in terms of criteria for equipment selection.

Chapter IV describes a number of examples of the use of small-scale computing equipment in information handling. The chapter concentrates on the more unusual (and often undocumented) projects and, therefore, deals primarily with microcomputers.

Chapter V looks at current trends in the development of information systems and services, and tries to predict those changes which are likely to have a considerble impact on information handling. The effects of those changes on the education of information professionals is considered.

Chapter VI makes a number of recommendations concerning further investigations, education and training requirements and standards for systems and documentation.

A number of annexes are appended to the report. They provide the reader with background detail and deal with terminology, minicomputer manufacturers and microcomputer systems.

CHAPTER II

THE IMPACT OF COMPUTER TECHNOLOGY ON INFORMATION HANDLING

Computers were first applied to information storage and retrieval systems in the late 1950's when a number of systems were developed in the U.S.A. by the Armed Service Technical Information Agency (now the Defense Documentation Center), National Ordnance Laboratory, National Aeronautics and Space Administration (NASA) and the National Library of Medicine (NLM). The system developed by the National Library of Medicine - Medical Literature Analysis and Retrieval System (MEDLARS) - was the largest of these, both in terms of the size of its files and in terms of its user population. MEDLARS was implemented in 1964 and was the first large computerised retrieval system to be made widely available without security and other restrictions.

The characteristics of the MEDLARS systems are typical of the information systems that became available during the 1960's. The systems were operated in an off-line batch processing mode. This technique of batch processing required data to be brought to a data centre where it was punched on to cards and these were subsequently read into the computer. The desired program, usually stored on magnetic tape, was also selected and entered from the tape into the computer memory. The program acted on the data and the results of the processing were output via a printer, or sometimes stored on a second deck of cards for further processing. The user of the data then came to the data centre to collect the results. This form of processing worked quite well for applications that occurred at periodic intervals.

The MEDLARS system was originally designed, not as a retrospective search system for bibliographic material, but as a publication system to produce the printed index, Index Medicus. The computer was used to manipulate bibliographic records in machine-readable form. It was used to check for errors, perform sorting and formatting and to interface directly with photocomposition

equipment. To do this it was necessary to put the index records into machine-readable form and then update, say monthly. Once this was done and the index produced, for example monthly, then a machine-readable database was available for exploitation.

These databases could be used in a number of different ways. First, they could be used to conduct retrospective searches. These are searches through a body of recorded literature to find items on a specifically defined topic. Another application was the selective dissemination of information (SDI), as suggested by Luhn in 1958. In SDI, the current interests of users or groups of users are defined in an "interest profile" which is stored in machine-readable form. After the database has been updated, the additions are checked against the interest profiles. Matching records are printed out and sent to the appropriate users, thereby enabling them to keep up-to-date with the literature of their field on a regular basis.

Although the computer offered many advantages in information handling activities the off-line batch processing systems have considerable disadvantages. Most significant is the delay in obtaining results, and if the search was unsuccessful on the first run, then it may have to be modified and reprocessed. In the same way, there is no facility for browsing through the literature. There was clearly room for further development of systems.

In the early 1950's, it occurred to a number of people that the computer could be more useful as a tool for researchers if simple problems could be handled without a formal batch operation. Teletype terminals were sited in laboratories at Massachusetts Institute of Technology (MIT) and these enabled researchers, each from his own teletype, to program the computer remotely. The computer would process each program in turn and return the results to the appropriate user's teletype as printout. This development marked the introduction of the on-line systems we are familiar with today.

The term "on-line" refers to the searcher being in direct communication with the system he wishes to use. The user provides input to the system and it, in turn, reports back to the user. The user then makes decisions based on that report and provides further input. For this reason the system is also referred to as being "interactive" or "conversational". The development that enabled such systems to become feasible was that of timesharing. This means that the processing time of the computer is shared among several completely independent activities. Each user is unaware that there are other simultaneous users of the system as the processor spends only fractions of seconds with each activity in turn before proceeding to the next.

The first large scale on-line information storage and retrieval system was the Remote Console (RECON) system of NASA. Experiments with the system started in 1965 but it did not become fully operational until 1969. Since then, the number of publicly

available databases has increased considerably: in 1979 Williams[1] estimated that 570 bibliographic databases were available on-line.

All these activities were carried out on mainframe computers and, to a large extent, still are. However, the late 1960's saw the introduction of minicomputers which were initially developed as low cost computers with a minimum of processing power and memory. They were used primarily for control processing. This form of processing differs considerably from batch and timeshare processing. Data from the process to be controlled are made available to the computer, usually via an analog/digital converter, in a digital form that can be interpreted by the computer. The computer must periodically (at least once every second) sample the sensor devices to upgrade the computations and perform appropriate controlling actions e.g. reducing electrical current, switching off the power etc.

It was soon recognised that minicomputers had a potential use in a number of unrelated areas and that they should be adaptable to the requirements of each. This resulted in a number of general purpose minicomputers being developed and software being "unbundled". Previously, machines were sold for specific applications with software provided as part of the overall system package - all "bundled in" together.

The advances in computer technology that have had a significant impact on information handling can be separated into three categories as follows:

i) processing

ii) storage

iii) communications.

Processing

The first computer, ENIAC (Electronic Number Integrator and Computer), was completed by 1946. It consisted of about 16,000 vacuum tubes and was very large, requiring a room 60 feet by 25 feet to hold it and it weighed more than 30 tons. This computer (and others based on vacuum tube technology - later known as "first generation computers") had high power consumption, were extremely unreliable with failures every few hours or so and required cooling plants often as large and complex and the computer itself.

Two years later the first transistor was developed at the Bell Telephone Laboratories in the U.S.A.. Transistors, whilst comparable to vacuum tubes in terms of the tasks they could perform, required much less electrical power, generated very little heat and were more reliable. They became the basic component of the "second generation computers". The digital computer provided a large potential market for the transistor, the reason being that

digital systems require large numbers of active circuits. Each computer was made up of several thousand printed circuit boards. These were cards on which the various electronic components (e.g. transistors, resistors, capacitors etc.) were mounted and interconnected. The cards were then slotted into frames and wired together to make up the computer.

Early efforts to miniaturise electronic components were not motivated by computer designers and engineers. Various satellite and missile projects, however, called for complex electronic systems to be installed in equipment in which size, weight and power requirements were severely constrained and so the effort to miniaturise was promoted by military and aerospace agencies.

The most recent solution to miniaturisation involves the semiconductor integrated circuit. Several researchers saw that the characteristics of semiconductors such as germanium or silicon that had been exploited to make the transistor might be further exploited. The physical composition of semiconductors contained equivalents of resistors and capacitors, and by combining them with transistors in the same material complete circuits could be created in a single piece of semiconductor material.

The integrated circuit was the basic component of the "third generation computers". In the early 1970's integrated circuits were being produced with about 1000 components. The first microprocessor was developed by Intel Corporation in 1971, was about ¼ inch square and carried the equivalent of 2250 transistors. By 1976 large scale integration (LSI) produced chips carrying over 30,000 components and by 1980 very large scale integration (VLSI) saw chips with over 1 million (10^6) components. The increase in the number of components per chip over time is shown in Fig. 2-1.

The individual elements on the silicon chips are defined by a photographic process. The smallest component dimensions on the chips are currently 3-4 micrometers (1 micrometer = 1 millionth of a metre). It is expected that this will be reduced in the near future to less than 1 micrometer and that by the late 1980's it will lie between 0.05 and 0.005 micrometers. As a guide to the significance of these dimensions, Kubitz[2] compares them to the average size of a human hair which is 80 - 100 micrometers in diameter. The trend of component size reduction over time is shown in Fig. 2-2.

The substitution of microelectronic devices for individual discrete components reduces costs not only because the devices themselves are cheaper but for a number of other reasons. First, many of the interconnections that were previously required are now contained within the integrated circuit, which saves labour and materials. These interconnections are much more reliable than solder joints or connectors, which saves on maintenance. Integrated circuits are much smaller and consume much less power than the components they have displaced. They make savings possible in support structures such as cabinets, racks, power transformers and

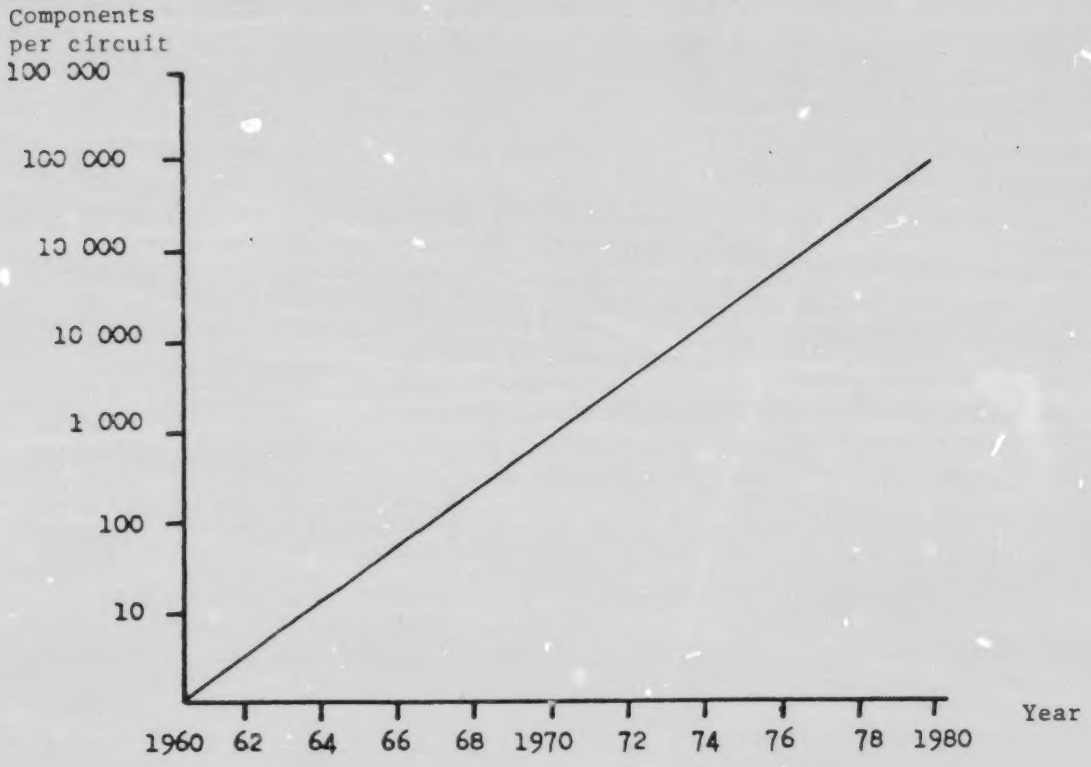

Fig. 2-1 Increase in the number of components per chip

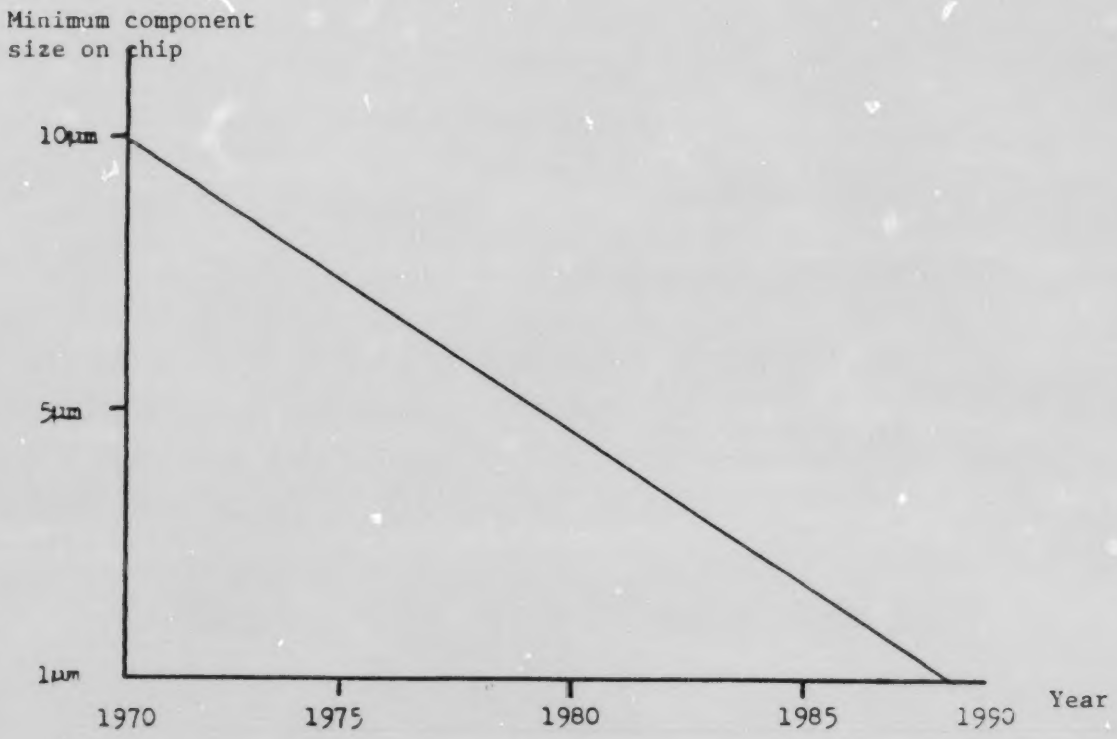

Fig. 2-2 Decrease in component size over time

cooling fans. Less intermediate testing is needed during the course of production because the correct functioning of the complex integrated circuits has already been ensured. Finally, the end user needs to provide less floor space, less operating power and less air conditioning for the equipment.

The most striking characteristic of the semiconductor electronics industry has been a persistent and rapid decline in the cost of a given electronic function together with a similarly persistent gain in their reliability. These trends are demonstrated in Figs. 2-3 and 2-4 respectively. These two figures show trends for each of the four distinguishable technological bases: vacuum tubes, transistors, small scale integrated circuits, and large scale integrated circuits. Fig. 2-3 shows the relative reduction in cost per component and Fig. 2-4 shows the decrease in relative failure rate of individual components (which is inversely proportional to the reliability of individual components). A typical example is the hand-held calculator whose cost has declined by a factor of 100 in the last ten years. The primary means of cost reduction has been the development of increasingly complex circuits that lower the average cost per function. The main technical barrier to achieving more functions per circuit is "production yield". More complex circuits result in larger devices and an accompanying increase in the probability of defects (these are defects in the crystal structure of the semiconductor material which cause the circuits to malfunction) so that a higher percentage of the total number of devices have to be scrapped during production.

Technological developments have concentrated on increasing the production yield either by reducing the density of defects or by reducing component dimensions. To reduce the defect density, it has been necessary to pay considerable attention to control and cleanliness. Most manufacturing operations must be carried out in dust-free environments. Reduction of the dimensions of the basic circuit components has been achieved by improving the resolution of the photoengraving process. Now, optical limits are being approached and methods using electron beams or X-rays are being developed to reduce the dimensions even further.

Storage

The technology of digital storage is probably the most rapidly changing sector in all microelectronics. Over the past decade, operating speed and reliability have been increased by at least an order of magnitude at the same time as physical size, power consumption and cost per bit of storage have been reduced by factors of up to 1,000. Similar improvements are predicted for the next decade before physical limitations are encountered. The cost per bit of computer memory for successive generations of random access memory (RAM) are displayed in Fig. 2-5.

The most widely used digital memories are read/write memories. These read and write at an identical, or similar, rate.

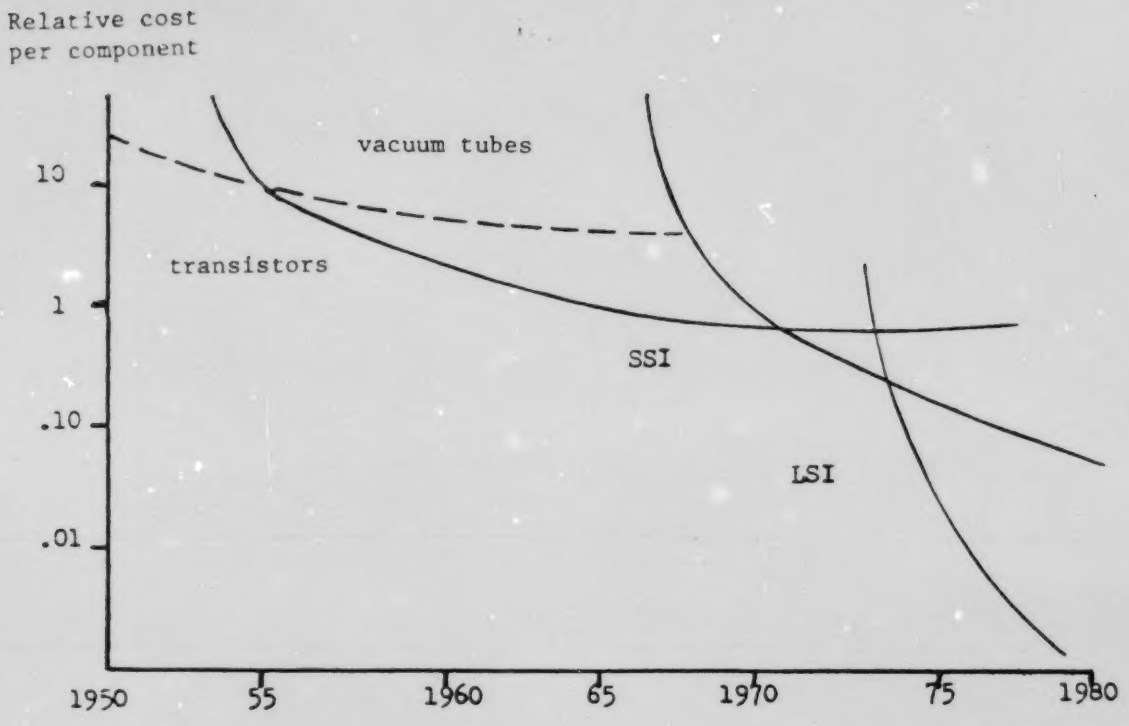

Fig. 2-3 Reduction in cost per component over time

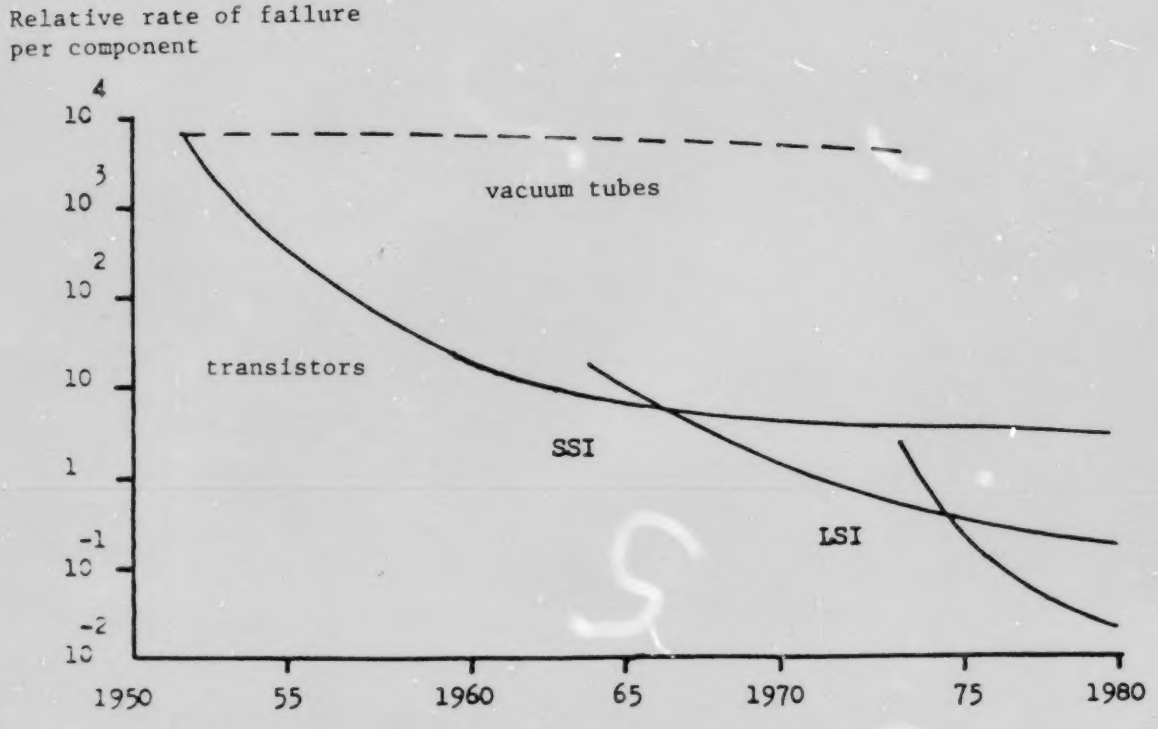

Fig. 2-4 Gain in reliability per component over time

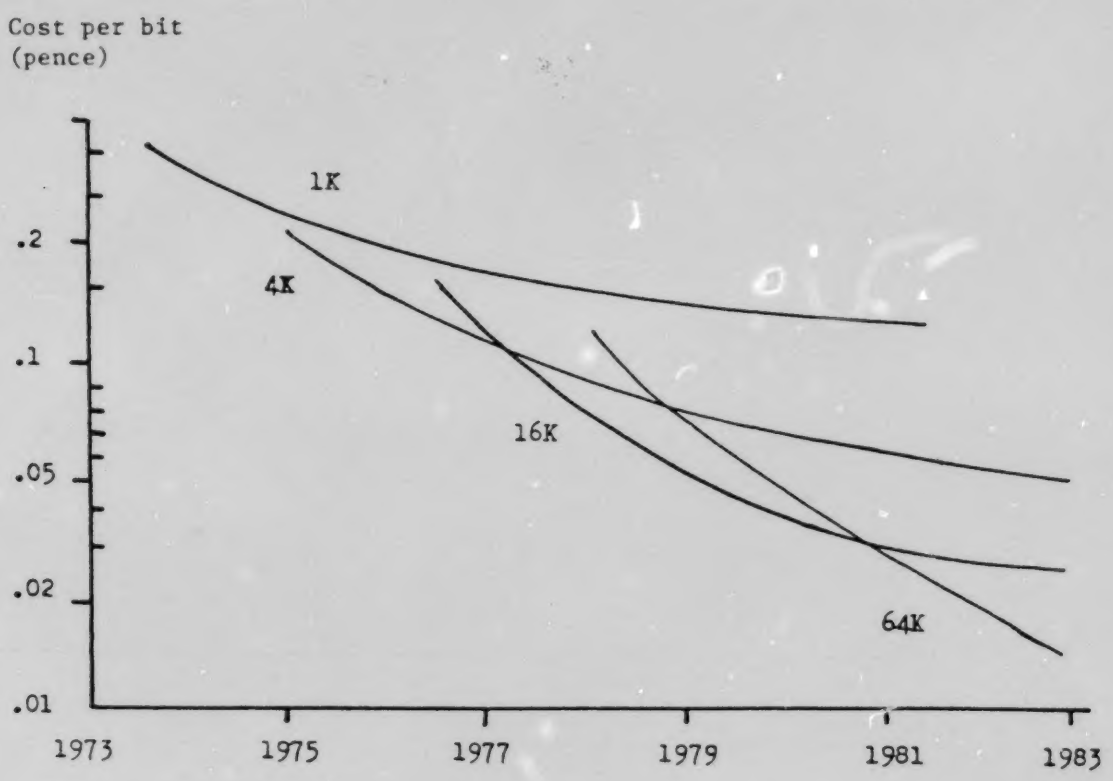

Fig. 2-5 Cost per bit for successive generations of RAM

Important characteristics for memories are storage capacity, cost per bit and reliability. Others are speed of operation (access time), cycle time and data transfer rate. Access time is the time it takes to read or write at any storage location. Some memories, such as random access memories have the same access time for any storage location. Serial access and block access memories have access times that depend on the storage location required. Random access memories can complete read or write operations in the specified minimum period known as the cycle time. Serial access and block access memories have a variable and relatively long access time after which the data transfer rate is constant. The data transfer rate is the rate at which information is transferred to or from sequential storage positions.

Digital memories can be divided into moving-surface devices or entirely electronic devices. Most common moving-surface devices provide information storage in localised areas of a thin magnetic film that is coated on to a non-magnetic supporting surface. The

magnetic material must be capable of retaining the recorded information even when the external power is removed. The supporting surface can be flexible in the form of a tape or disk made of plastic, or it can be rigid in the form of a disk or drum made of aluminium or similar material. The magnetic film and the read/write head (a small electromagnet) move in relation to each other to bring a storage location into position for the reading or writing of information, which is stored as tiny magnetised spots in the magnetic film. The stored information is sensed (read) as a weak electrical current that is induced in the read/write head as the magnetic film moves under it.

The simplest digital magnetic tape memories are adapted from audio cassette tape recorders. The speed of tape is limited by wear and heat as the tape is in frictional contact with the read/write heads. More sophisticated digital tape memories, and disk and drum memories also, hold the read/write head a few micrometers above the magnetic surface. This makes it possible to have higher speeds of access and improves the reliability of the store. Large magnetic disk memories store information on one or more disk surfaces mounted on a single spindle rotated by a motor. Access to storage locations is achieved by moving one or more read/write heads radially across the spinning disk or disks.

Information stored in magnetic media is usually retained when the external power is switched off. Such storage is said to be non-volatile. It is normally feasible to remove the tape and disks from the system and to physically transfer information from one location to another and access to almost unlimited quantities of information can be achieved by the interchange of disks and tape reels. Such properties are rarely found in electronic memories.

The cost per bit of information in moving-surface memories is lower by 1 to 4 orders of magnitude than that of information stored in electronic memories as indicated in Fig. 2-6. Continuing improvements are being made in the cost per bit, data transfer rate and the reliability of moving-surface memories. Microelectronic fabrication technologies are helping to shrink the size of the read/write heads, yielding higher bit densities on the recording surfaces. Microelectronic circuits also serve to implement error-correcting codes in moving-surface memories, substantially reducing the rate at which errors are made in the complete storage and retrieval process.

The newest electronic memory systems have been made possible by modern semiconductor technology. In the 1950's and 1960's electronic memories were arrays of cores (rings) of ferrite material a millimeter or less in diameter, strung on a grid of wires. Ferrite core memories have now been succeeded, on the whole, by semiconductor memories which provide faster access to data, smaller size and lower power consumption at significantly lower cost.

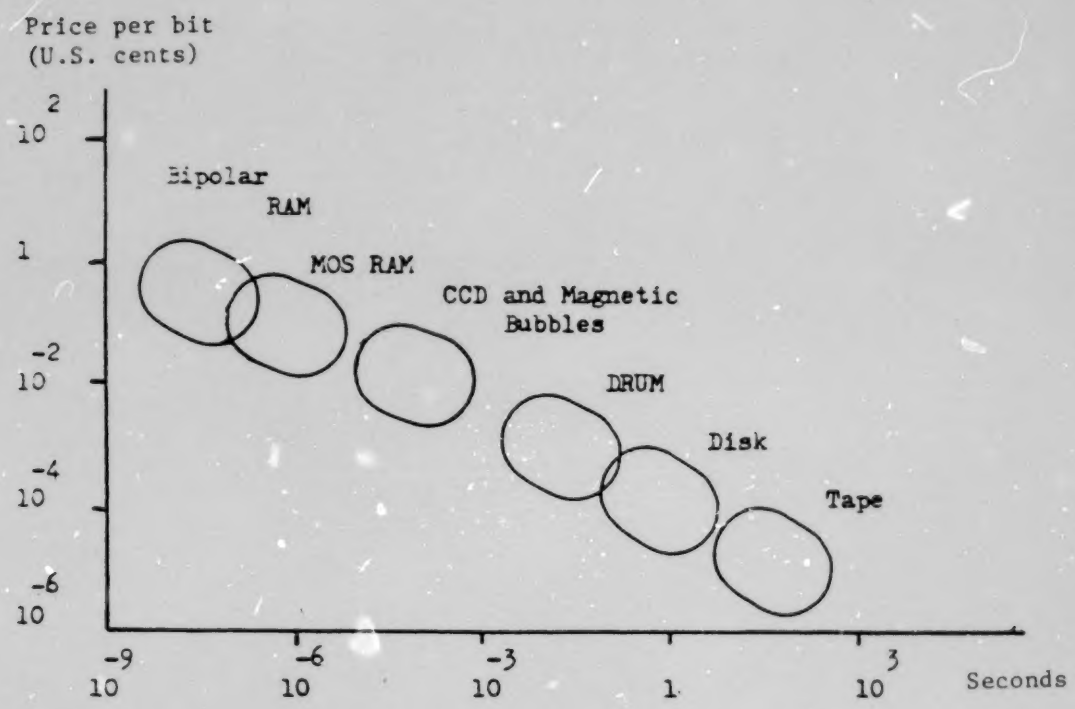

Fig. 2-6 Memory cost versus access time

The most widely used form of electronic memory is the random access read/write memory made in the form of a single large-scale integrated memory chip capable of storing as many as 16,384 (16 K) bits in an area of less than half a centimeter square. A number of individual circuits, each storing one binary bit, are organised in a rectangular matrix. Access to the location of a single bit is provided by an address presented as input to an "address decoder" which selects one row and one column for each read or write operation. Only the storage element at the intersection of the selected row and column is the target for the reading or writing of one bit of information. A control signal determines which of the two operations is to be performed.

A simple one transistor storage cell is widely used in the most economical random access read/write memory devices. Information is stored as an electric charge. This electric charge can leak away gradually over time. To compensate for this leakage, the stored charge needs to be regenerated (usually every

two milliseconds). In addition to the continual slow leakage, each read operation causes more of the charge to leak away (reducing the charge by a factor of 10 to 20) and the stored information must, therefore, be regenerated after each read operation in order to be retained.

The semiconductor memory chip with a single transistor in each storage cell is one of many designs. Cells with two, three and more transistors offer additional features but with the penalty of increased silicon areas (increasing the likelihood of defects) and cost. Metal-oxide-semiconductor (MOS) technology storage cells with three transistors amplify the voltage of the stored signal making the "read" signal easier to detect. However, refreshing the signal for leakage is still required.

Memories that do not require refresh operations are called static memories. Such memories have almost negligible power consumption and require only a minimum of support circuitry (only the address decoders - no refresh circuits) but are more expensive than volatile memories. This technology is known as Complementary-MOS (CMOS).

The memories with the highest speed of operation usually employ bipolar transistor technology rather than the slower MOS or CMOS technologies. The higher speed is attained at the expense of more complex and costly manufacturing processes and higher power consumption. A recently developed version of the bipolar transistor technology is integrated injection logic (I^2L) but this has not yet been proven advantageous over the older bipolar technologies. Fig. 2-6 displays the cost/speed tradeoffs for alternative memory technologies.

The most dramatic changes in cost per bit have been for MOS random access memory. These changes are shown in Fig. 2-7. The reason for the dramatic reduction in cost is the increased capacity of a single chip of semiconductor RAM. Most of the increased capacity has been achieved through higher density on the chips and not by using larger chips. The trend in increased chip capacity is shown in Fig. 2-8.

Some applications require random access memories containing permanently stored or infrequently altered information. Such storage is provided by read-only-memories (ROMs). Information is placed in the storage matrix when the chip is manufactured. Alternatively, the memory cells can be made with small fusable links. A pattern of stored information can then be placed in the matrix by applying a series of electrical signals sufficiently strong to blow out the unwanted fuse connections. Fusable-link memories are one type of programmable read-only-memory (PROM).

Another variation on the read-only-memory is the erasable programmable read-only-memory (EPROM) which is required when read operations are much more frequent than write operations. Optically

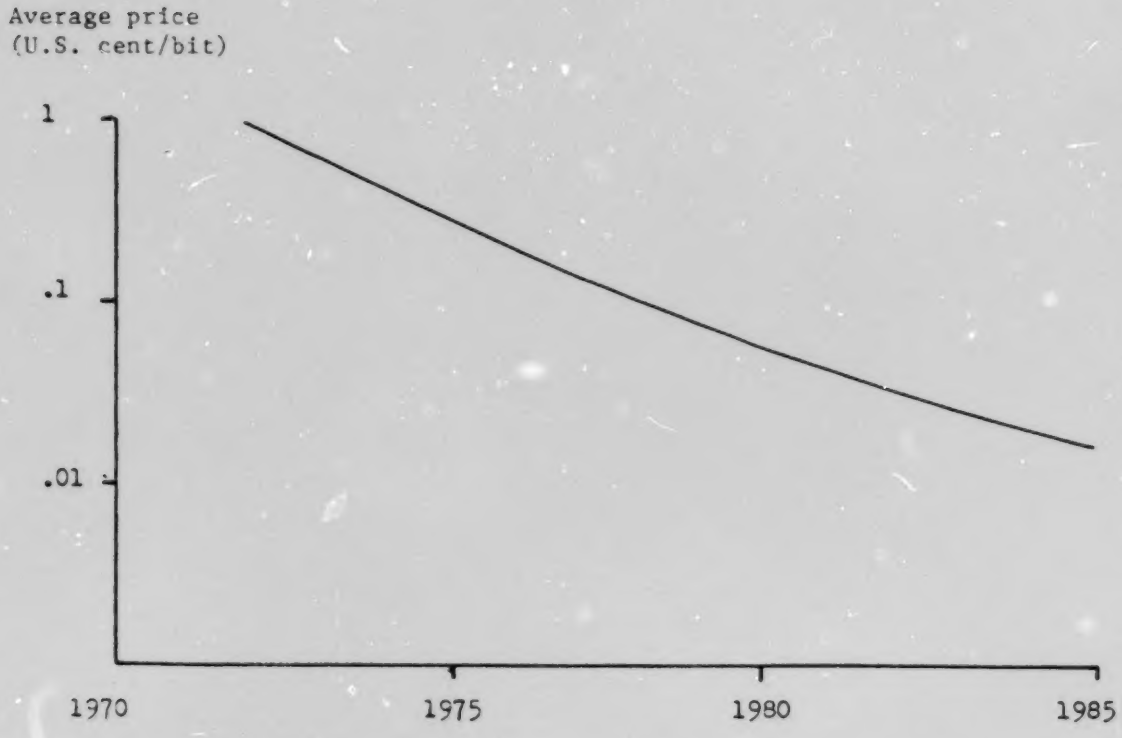

Fig. 2-7 Projected semiconductor RAM price

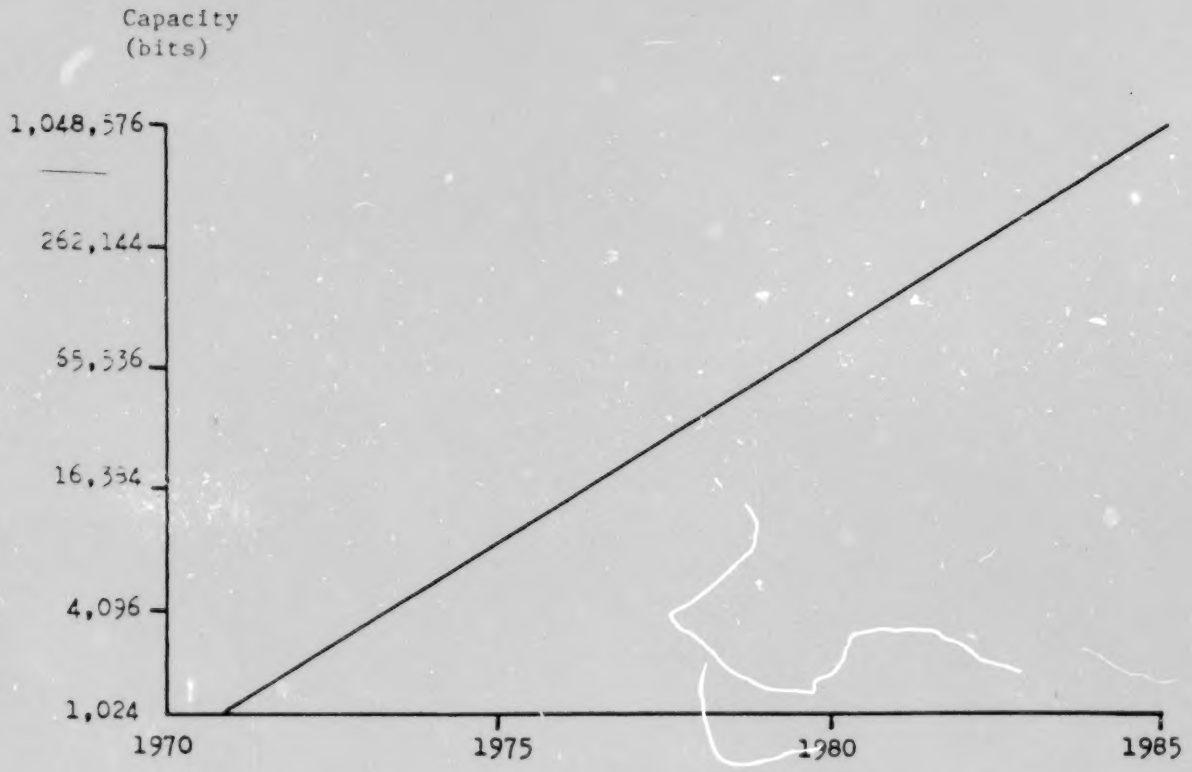

Fig. 2-8 Projected memory chip capacity

erasable read-only-memory is read and written electronically but, before a write operation, all the storage cells are erased to the same state by exposure to ultraviolet radiation. (This makes the semiconductor material sufficiently conductive to allow the charge to leak away thereby erasing the previously stored information).

An alternative is the electrically alterable read-only-memory (EAROM) which can be altered without the necessity of erasing the entire store. However, EAROMs do not yet have the features of low cost, fast writing, long term retention, and reliability after successive erasures that are required. Consequently, EAROMs are not widely used.

Several new types of memory device are just becomming readily available but have not yet had sufficient time to make significant impacts on information handling procedures. However, their potential impact is considerable. These new devices are the bubble memory, charge coupled device, and optical disk and they are discussed in detail in Chapter V.

Communications

Most data communication systems currently under development are based on the concept of packet switching. This is the technique of data communication wnere information is transmitted between a source and destination in short segments called packets without the need to reserve a physical circuit. This "virtual circuit" has the appearance of a direct connection to the user. The decoupling of the source and destination at network nodes enables the use of different transmission speeds, codes and communication protocols in the intercommunication process. Packet switching thus addresses the basic user problems of how to achieve compatibility whilst retaining maximum flexibility in the use and configuration of data communication systems. It also optimises the use of interconnecting communication circuits between switching nodes resulting in substantial financial savings when compared with dedicated circuits.

The rationale for packet switching is that the actual time required to transmit a message is very short in relation to the time required to establish a conventional end-to-end call and that it is more economical to transmit the message stage by stage through the network, storing the message segments at each node until the necessary line capacity is available for transmission to the next node. It is now possible to purchase services from a commercial packet switched communications network, for example, Euronet/Diane (Direct Information Access Network for Europe).

The major trend in telecommunications at present is the fundamental shift from analog to digital modes of transmission. The new transmission channels (based on optical fibre technology) will have enormous capacities. The shift involves all types of communications - voice, facsimile, computer transmissions, television communications, microwave and satellite communications and radio links. Digital circuits are less prone to noise than analog ones and their cost/performance ratio is continually improving.

One of the growing applications of communications systems to information handling is the provision of electronic mail services. It is possible to convert any type of message into digitised form for transmission. Naturally, different messages require varying numbers of bits for their representation, for example:

high quality colour photograph	2 million bits
newspaper quality photograph	100,000 "
colour television frame	1 million "
brief telephone voice message	1 million "
document page in facsimile form	200,000 "
document page in computer code	10,000 "

coded request for library document 200 bits

To some extent, the microprocessor counteracts the rapid growth of computer communications networks. The central idea of networking is to share both functions and data. As small computer systems have become more powerful and compact, they have also become more independent in function. People are now able to buy low cost computers to solve most of their problems. The general trend is towards data sharing across networks and away from network designs based on functions shared over a network of computers.

On the other hand, certain applications of microprocessors have opened whole new vistas for the transfer of information by telecommunications. The development of the central processing unit (CPU) on a microprocessor chip has led to home microcomputers and television-based information terminals costing up to about 3,000 U.S. dollars. This trend toward inexpensive machines with communications, file storage, and processing capacity requires a reassessment of the economics, convenience, movement and storage of information. A balance between convenience and economics should be struck in deciding the amount and kind of information to be stored and processed locally in the microcomputer and the kind to be accessed through a telecommunications link, usually a telephone line.

From the viewpoint of information processing it is convenient to discuss Videotex and teletext together with microcomputer systems, since the former two types of home-based information system result from the overall technological trends in machine communication even though most of the terminals they employ are not microcomputers in the strict sense of the term. Although their services and underlying technology differ, both Videotex and teletext are accessed through the adapted domestic television set, distinguishing them from other home information utilities that require computer terminals.

Videotex (sometimes called viewdata) is an interactive medium linking relatively large computer databases to televisions through the switched telephone network. The United Kingdom, France and Canada are developing systems of their own and are selling the technology to other nations.

A variety of Videotex systems exist but they all operate in basically the same way. To access those messages transmitted via the telephone network, users must have special decoders built-in or attached to their television sets. To connect to the central database the user must first dial the appropriate telephone number and place the receiver in a modem or acoustic coupler. When the conncetion has been accomplished successfully, an index page appears on the TV screen and users begin to search for the information they require by pressing numbered keys on their hand-held control panel (the keypad). Instructions appear on the screen telling the user which keys to press for particular types of data.

The central Videotex database may contain an almost unlimited amount of information provided by sources ranging from local newspapers to travel agents, shops and libraries. The data are stored in "frames" or screenfuls and can be updated instantly. Several frames of information on the same topic comprise a "page" and may be accessed sequentially.

To retrieve information from the database, the users employ a "tree structure" search method, starting with broad subject headings and narrowing down their choices until they arrive at the frame of information they require. Such systems, as currently designed, are fairly limited in capability and have no cross-referencing.

Unlike Videotex, teletext is a non-interactive system linking the information provider to the home via a regular or cable TV broadcast signal. Once again, only TV sets with special decoders are able to pick up teletext.

Pages of information are broadcast, one at a time, in recurring cycles. To access them, users consult a contents page, then use the keypad to key in the numbers of the pages to be retrieved. The decoder then selects the appropriate pages when they cycle by and the information is displayed on the TV screen.

Teletext's chief virtue is its ability to be updated continuously for a large viewing audience. It can provide users with the most current information on a range of subjects and is easily accessible. Because it is broadcast rather than telephone-based, teletext is also less expensive than Videotex which requires users to pay for the telephone service and for each individual frame accessed.

Teletext has disadvantages, the greatest being its limited database size. To access information, users have to wait until the specific page they are seeking cycles by, giving the decoder time to read, decode and display the data. The wait time becomes excessive when the database exceeds about 100 pages. Thus, teletext is severely limited in the amount of information it can carry efficiently.

Overall trends

The overall effect of these advances in processor technologies on information handling has been the reduction in size, cost and operating requirements of digital computing equipment. Prior to the late 1960's equipment had been far too expensive to justify use for what were then considered "peripheral applications" of information handling. However, by the mid-1970's many information handling organisations were able to justify the cost of purchasing computing equipment either alone, or as part of a co-operative. Many large libraries and information services have their own small-scale equipment as demonstrated by Grosch[3], but the continued

reduction in size and cost of equipment is beginning to influence the small and special libraries in particular (as indicated in Chapter IV).

The overall effect of advancing digital memory technologies on information handling is an increase in the capacity and reliability of information systems, faster and more efficient retrieval of information (although, because of increased capacity of storage, searches are made through larger volumes of information and the faster access times may not reduce retrieval times as far as the user is concerned) together with an accompanying decrease in cost.

Developments in the areas of processing, memory and storage, and communications interact to produce some very sophisticated information systems. On the whole, these systems are more compact, less expensive, considerably more reliable, store vast quantities of information and offer new types of information service in addition to traditional services. Moreover, access to the systems from remote locations is simpler and more efficient than ever before. Can we cope with the volumes of stored information that are available to us?

It is interesting to note that, with the emergence of new technologies, there has been a fundamental shift in the concerns of the information profession. This shift can be expressed, in simple terms, as a change from the attitude - "How can we give the user more information to solve his problem?" to - "How can we make sure that the information we give the user is accurate, reliable and up-to-date?". The basic question concerning the organisation, classification, indexing and retrieval of information are regaining importance having been overshadowed, over the last few years, by the concerns of automation of systems and services.

The change in prevailing attitude to provision of information services has serious implications for the training and education of information workers. While it has been recognised for some while now that courses concerning information handling should include some element of computer programming, systems analysis and automation, and computer appreciation, the courses of the future do not need to give the same emphasis to those elements. As systems adopt standards and incorporate more sophisticated facilities, they become easier to use and the intensive training previously required is no longer necessary. In fact, with the increasingly "user friendly" systems that are emerging, much of the training in systems' use can be conducted by means of a user/system interaction (see Chapter IV for a detailed evaluation of the potential of computer-aided-instruction).

CHAPTER III

MINICOMPUTERS AND MICROCOMPUTERS

Minicomputers have been attacking the traditional market areas of the large mainframe computer for a number of years. Two trends in particular suggest that minicomputers will continue to dig into the medium-scale computer market at the expense of mainframes. These trends are

i) the improving functional capability of the mini

ii) the increasing realisation among the user community, of the benefits to be derived from decentralised, distributed processing, using low-cost minis as opposed to the conventional approach of timesharing a single, large centralised system. These benefits include improved cost/performance, reliability, availability and flexibility.

Recently, the minicomputer manufacturers themselves have had to face a serious threat to their own traditional market areas in the form of the large scale integration (LSI) microprocessor.

Definitions

A minicomputer is a digital computing machine made up of a central processing unit (CPU), memory, and input and output devices. The distinction between minicomputers and large mainframe computers is essentially one of size: physical size, memory size, word length, storage capacity and cost. The problem lies in defining the boundary between minis and mainframes for each of the above characteristics.

Over the last few years, a number of definitions of the term "minicomputer" have emerged, none of which is entirely satisfactory. Auerbach[4] bases his definition on cost and memory size:

"A minicomputer is a small, stored-program digital computer that can be programmed in an assembly or higher-level language and which has the following attributes:

1. Sells for less than 25,000 U.S. dollars (in 1974) for a minimum, stand-alone configuration comprised of a central processing unit, memory, input/output equipment, and system software.
2. Contains a memory of at least 4,000 eight bit words.
3. Performs normal computer functions (inputs, transfers, stores, processes, and outputs data) under stored program control.
4. Is usable in a broad range of applications."

Demitriades[5] draws somewhat different boundaries:

"What is a minicomputer? In general terms, it is a physically small, relatively inexpensive, highly reliable computer that has a stored program capability and requires little or no environmental control. However, the range in cost and capabilities is very broad...There is, however, a 'most common package' covering approximately 80 percent of the minicomputers in use today (1974 - author's addition). Its basic unit price range is from 2,000 to 10,000 U.S. dollars; a workable system with memory and peripherals will cost about 20,000 U.S. dollars. The size of a television set, it will store about 4,000 words of 16-bit memory and process at about 5 millionths of a second (cycle time for a basic operation - author's addition). Its modular design allows for easy add-on."

Other definitions are based on the variety of minicomputer applications. For example, Snyder[6]

"An acceptable definition of the minicomputer is elusive...Most quoted of the suggested specifics are: a core size of 4,000 to 8,000 words, and a selling price somewhere in the vicinity of 5,000 U.S. dollars (in 1975) ...they're usually referring to a central processor, with 4 to 8K (words) of core memory and possibly a teletype....However, it's not a functional machine. When you talk about a true mini business system, you have to include a general purpose computer and the normal input and output devices...and considerably more than 4 to 8K...The definition must be qualified to any computer system that is capable of handling typical business applications - billing, payroll, inventory control etc. - and that can be purchased for a total cost of less than 100,000 U.S. dollars or rented for less than 2,000 U.S. dollars a month."

The basic problem with definition is that the term "minicomputer" was never intended to refer to a particular class of computer with well defined specifications. Rather, the term tended to evolve in reference to the enormous growth in the whole lower end of the computer market.

The two major characteristics of minicomputers are flexibility and low cost. In 1974 Auerbach[4] reviewed minicomputer features that were contributing factors to the low cost of minis vis a vis large mainframe computers.

"1. All have simple, i.e., limited, instruction sets, both in absolute number and the power of instructions provided.
2. All have small memories...
3. Word length is short, which permits design economies in the central processor electronics.
4. All have simple input/output (I/O) control capabilities.
5. Elimination of such features as real-time clocks and parity checking from the basic standard (system by making them) optional (tends to reduce costs).
6. Slow and relatively unsophisticated peripheral devices are used.
7. Minimum engineering support is needed.
8. A limited amount of comprehensive system software is supplied free with (each) system."

Some of these characteristics are changing with newer technologies. Minis are now available with larger memories, greater word length, more support software etc., and, as minis become more powerful, they increasingly resemble larger machines. The evolution of the mini has resulted in changes to the basic approach to computing. With the use of the mini, there is a shift from centralised computing, with many users interacting with one monolithic, centrally operated and controlled machine, to distributed computing where processing power is spread over a network of interconnected machines.

A further method of defining the minicomputer is by the type of application in which it is used. Historically, there have been three main application areas: process control, communications and conventional data processing.

a. Process control.

The first minicomputer applications were in the control of industrial and manufacturing processes during the mid-1960's. These early applications had a significant influence on the physical characteristics of the mini. Conditions encountered in navigation systems, in ships and aircraft, steel plant automation or oil exploration required equipment capable of withstanding wide temperature variations, excessive vibrations, mechanical shock, electromagnetic interference and wide variations of mains voltages.

b. Communications control.

By the end of the 1960's minicomputers were applied in communications control as front-end processors, concentrators and message switches. The function of front-end processors is to handle communications traffic to and from a large number of communication lines without involving the central computer system in details of the interface, line protocols etc.. These communications functions are taken on by the mini and the central computer system can receive large blocks of data at a high I/O rate.

As concentrators, minis accept data from a large number of slow speed terminals or communications lines and transmit these data to the appropriate destination over a single, high speed line; in the reverse direction, data are received over a high speed line and distributed over low speed lines to a large number of terminals.

In message switching, the minicomputer receives data from a number of different sources on either high speed or slow speed lines and retransmits these data to one or more destinations. The mini may also provide temporary storage in case of failures in the network.

c. Data processing.

There are three major factors responsible for the minicomputer's spread into the more general application areas of payroll, accounting, library automation etc.:

1. Evolution of more sophisticated operating systems in the late 1960's to early 1970's. These were disk based, real time and timesharing.

2. Emergence of peripheral devices (printers, terminals, large disks) with the same stringent environmental specifications.

3. Dramatic reduction in price, weight, physical size and power consumption.

This wide variety of applications again makes the distinction between minicomputers and conventional mainframes less clear.

It can be seen from the preceding paragraphs that it is almost impossible to arrive at a rigorous definition of the term "minicomputer". However, it is feasible to produce a general working definition of the term. For the purposes of this study, the following definition has been derived:

A minicomputer is a small, general purpose computer that does not require carefully controlled environmental conditions for operation, and which can be used in a variety of applications.

Since their emergence in the 1960's, minicomputers have evolved through successive generations. Today, "minicomputers" are flooding on to the market at a tremendous rate, resulting in much concern about the possible socio-political ramifications of their large scale use[7]. Potentially affected areas are being carefully scrutinised by governments, trade unions and educators.

The terms "microcomputer" and "microprocessor" are often used interchangeably. A microprocessor is a central processing unit on a single LSI chip. A microcomputer is a computer based on a microprocessor CPU i.e. a microprocessor combined with memory and I/O devices.

As well as the confusion between the terms "microprocessor" and "microcomputer" there is also a difficulty in distinguishing between "microcomputer" and "minicomputer". Some view the microcomputer as the lower end of a hierarchy of machines defined primarily by cost and word length as indicated by Fig. 3-1.

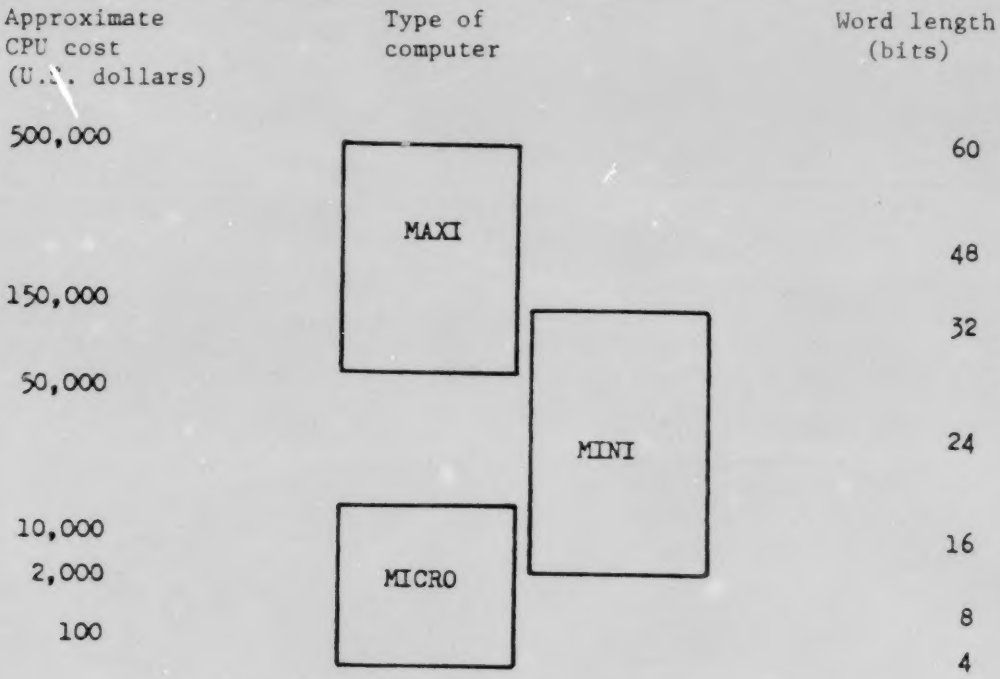

Fig. 3-1 Overlapping computer categories

It is probably more realistic to view the microcomputer as one more stage in the evolution of minicomputers. So the definition of a microcomputer arrived at for this report is:

A microcomputer is a minicomputer that has a microprocessor CPU.

Yet another term that requires clarification is "personal computer". The distinction between microcomputers and personal computers is one of marketing strategy. The personal computer has been promoted as a hobbyist's machine and tends to occur at the

bottom end of the price range. The personal computer is generally sold as a complete package - hardware and software. Their low cost and relative ease of use have contributed to their application in small organisations and small businesses. (Chapter IV describes some particular examples of their use).

Minicomputer characteristics

Detailed descriptions of minicomputers are presented by Paker[8] and Young[9]. Minicomputers have the same basic components as large scale computers, Fig. 3-2.

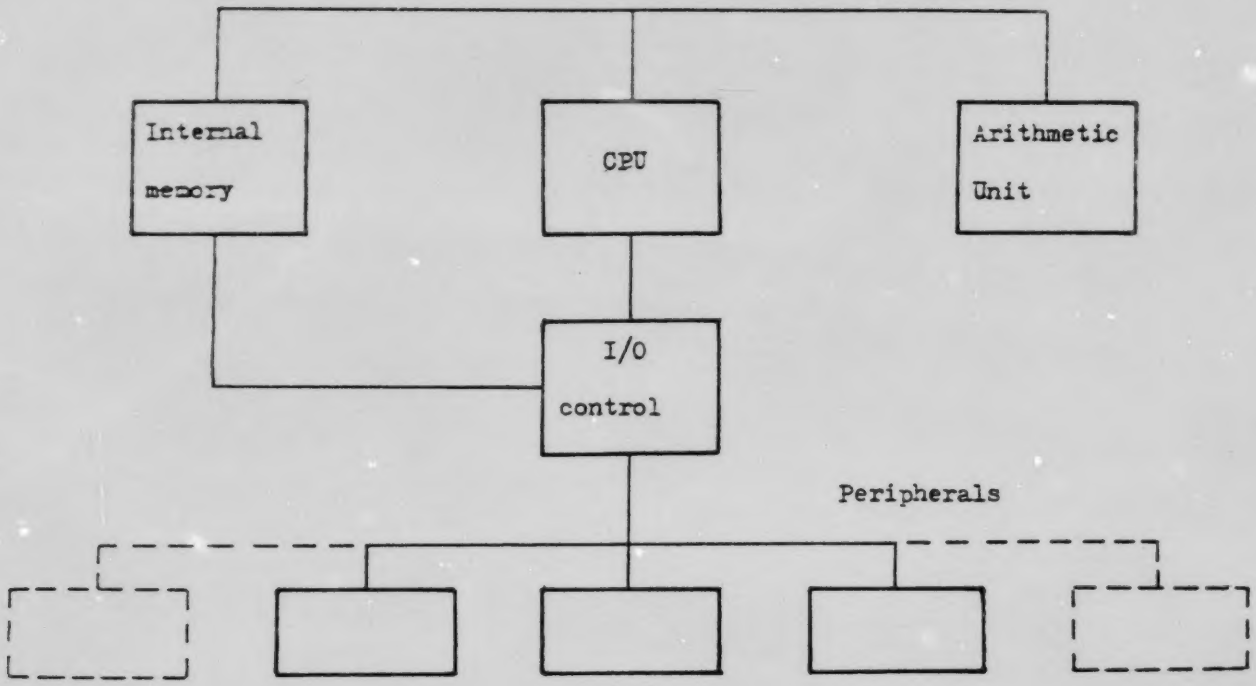

Fig. 3-2 Basic components of a computer

The software for minicomputers is also essentially the same as for large machines. It includes library subroutines, assemblers, compilers, file management programs and operating systems as well as the applications programs. The remainder of this chapter will consider various characteristics of minicomputers that can be used as criteria for equipment selection. With over a thousand minicomputer models on the market, choosing the appropriate system for a particular application is not easy.

The design characteristics of minicomputer systems were divided into six general categories by Young[9]. These categories are:

means of inputting
types of outputs
file structure and size
transaction volume
applications characteristics
interfaces to other systems

a. Means of inputting

The input to a system involves moving information into the computer. The information is initially in a form the user can easily understand such as lists, graphs etc., and has to be translated into a form easily accepted by the computer. The aim of most computer systems is to make the input process as efficient as possible.

The entire information handling process at input includes data collection, transcription (coding), keying in, verification, error correction, and transmission for processing. Such processes can be extremely costly in terms of time. Cox, Dews and Dolby[10] state that "in a computer system, the most time-consuming and expensive single operation is probably the original preparation of the data in machine-readable form". There are a number of factors to be taken into consideration in attempting to reduce these costs.

First, is the nature of the information itself. Most of the records will contain both alphabetic characters in upper and lower case as well as numerics and special characters. Some terminals e.g. teletypes, have upper case character sets only although most now have both upper and lower case. Special characters are still a problem, particularly with microcomputers.

Input can be achieved either in batch mode or in interactive mode. In batch mode, the data are usually prepared off-line and batches of data are entered into the system as high-volume input. Alternatively, individual data can be keyed into the system directly and held for later batch processing. In interactive mode, input is performed by means of a user/system dialogue. Questions are posed by the system and answered by the

user, for example in filling out pre-formatted forms. Errors can be flagged by the system and corrected immediately by the user, making editing simpler. However, the interactive mode requires longer periods of computer use for data entry. Batch input requires only one-way devices such as keyboards, keypunches, card readers and paper tape readers, but interactive input requires devices that can also immediately display the system's responses e.g. teletypes or terminals comprising keyboard and visual display unit (VDU).

Some applications can make use of several input devices. For example, a light pen and interactive terminal might might be needed for a circulation system in a library - the light pen to record data about the items being issued and the terminal to receive information about items on loan. The different input devices may input data at varying rates and the system must be capable of handling them.

Input stations can be located remotely from the mini-computer in which case communication links (usually telephone connection and modem) are required. If data are to be input from several locations, then the system must be capable of supporting timesharing operations.

To minimise the input procedure, it may be possible to obtain the data required, in machine-readable form, from other organisations. For example, it is possible to receive sets of MARC (machine readable catalogue) records from national agencies and library co-operatives. Either the complete MARC record or selected fields from the complete records can be retrieved. The retrieved sets can be transmitted directly from the originating computer system to the destination system via a telecommunications link, or can be transferred via a storage medium such as magnetic tape or punched cards or, more recently on floppy disk.

b. Types of output

The results of data processing by a computer can be output to the end user of the system or to another computer for further processing and/or storage. The most common form of output is hardcopy. Typically, such output is produced by a printer which is controlled by the computer. Various types of printers are generally available. A serial printer is one which prints one character at a time whereas a line printer prints whole lines at a time. Daisy-wheel printers are becoming more popular because of their flexibility. The daisy-wheel print heads, typically comprising 96 characters, can easily be interchanged with each other thereby producing a greater variety of high quality print. Other types of hardcopy output include cards, multipart forms, continuous feed stationery, envelopes and so on. If large amounts of hardcopy are required then the speed of the output device can be critical.

The most common form of output in on-line, interactive

systems is by means of a visual display unit (VDU). Characters are generated from a read-only-memory (ROM) and each screenful of data is kept in a buffer store and used to refresh the screen about 50 times per second. A number of VDU features must be carefully considered before selection. These include the character set (some microcomputers only generate upper case), the number of characters per line, the number of lines per screen, special display modes e.g. reverse video, blinking/non blinking, and even colour. Computer-aided instruction (CAI) applications, in particular, can benefit from the various display features.

Machine-readable output, like machine-readable input, can be through direct communication between computers via telecommunication links, or through a transportable storage medium. Machine-readable output can also be processed further as in computer-output-microform (COM) production, computer photocomposition or facsimile.

c. File structure and size

The information that is held in a computer system for storage, processing and retrieval (not necessarily in that order) is in the form of files. Each file is made up of a number of individual units called records. A record is the logical description of the items about which information is held. The records contain a number of related data elements, known as fields or subfields. These data elements are usually related by virtue of referring to the same individual item - a book, document, user, and so on.

The organisation of the records in a file is called the file structure. A sequential file is one in which the records are organised in linear order, and records can only be retrieved by searching sequentially through the file until the desired record is found. Such files can be implemented on punch cards, paper tape, magnetic tape, cassettes, diskettes (floppy disks), disks, and are usually used in batch mode operation.

Direct access file structures store the records at any available location and the access point to the record, together with its address (location), are held in a index. Retrieval is accomplished via the index and, as the index is more compact than the complete records, is more efficient than retrieval from sequential files. Direct access files are, therefore, usually used in on-line interactive mode and can be held only on disk-type storage devices.

The size of files also affect system design. Storage devices all have a maximum capacity as shown in Fig. 3-3. The size of the file, in characters, can be used to calculate the number of storage devices required. For on-line systems, the number of characters that must be available at any one time will influence the choice of storage device.

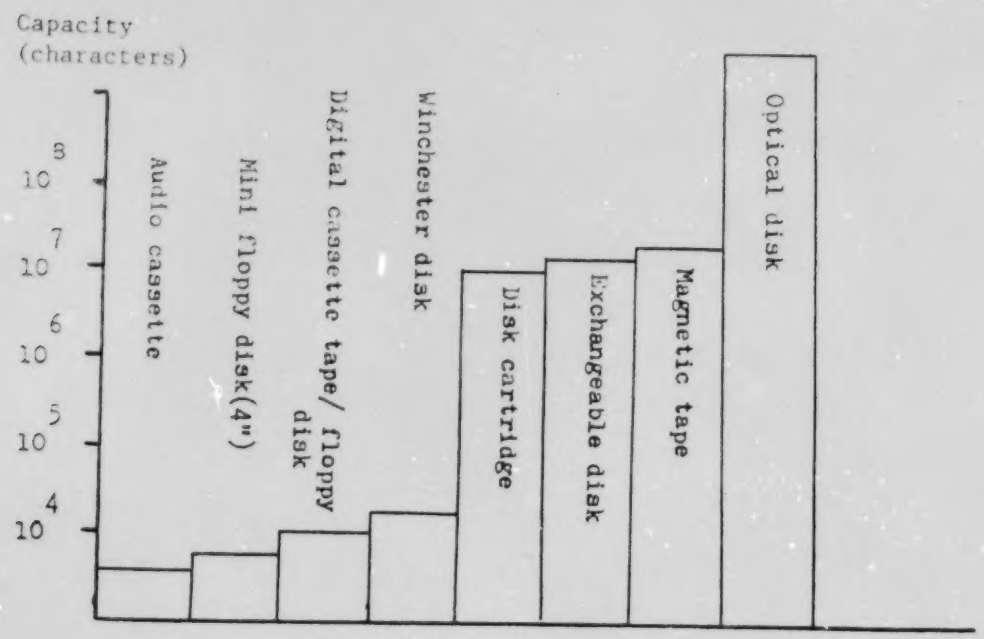

Fig. 3-3 Maximum capacity of storage devices

d. Transaction volume and processing characteristics

It is unlikely that any application (except perhaps instrumentation and process control) will impose an even load on the system over time. There are usually peaks and troughs of activity and the system must be capable of coping with these periods of high activity. However, it is difficult to quantify the expected loading. Not only must peak volumes be taken into consideration but the overall volume of activity might increase over time and the system may need to be expanded. Some mini-computers are modular and additional power, memory and workstations can be added with out too much upheaval.

An important factor in deciding on any system is response time. The response time in on-line systems degrades with increasing numbers of simultaneous users. Obviously, the rate of the degradation depends on the type and nature of the processing that each user is engaged in. A large number of users all doing

essentially the same task, e.g. editing or searching, will increase response times much less than the same number of users all doing various tasks.

Word size: This refers to the unit of information manipulated by the computer. Most microcomputers in common use today employ an 8-bit word length. The newest generation of microcomputers are 16-bit processors. Microminis and micromaxis are two new terms coined to describe the new 16-bit and 32-bit machines. Minicomputers have word lengths of 8, 12, 16, or 32 bits. The longer the word length of a computer, the greater the power of that machine and the faster its processing.

Memory size: The amount of main, high speed memory (the number of words - as referred to above - that can be stored and addressed directly) is determined by the size of the address register of the CPU. Most 8-bit microcomputers have a 16-bit address register, which provides 64 K words of memory. Some of the newer 16-bit CPU's have larger address registers and are capable of addressing up to 8 million words. Minicomputers generally have maximum memory sizes of 64 K to 256 K words, though larger memories are also becoming common.

Cycle time: The basic operations of the CPU are performed in a regularly times series of actions. The rate at which these are performed is determined by the clock rate or cycle time of the CPU. Today's microcomputers employ clock rates of 1 to 5 MHz (millions of cycles per second). Clock rates are increasing in new processors with a corresponding increase in computing speed.

Instruction set: The set of basic information processing operations that the CPU is capable of doing (e.g. addition) is known as the instruction set. This determines the machine language for the CPU. All programs that are run on a particular computer must be translated into the machine language for that computer. Minicomputers have more powerful instruction sets than microcomputers, although each generation of computers has a more powerful instruction set than the preceding generation. This has a major effect on the speed of operation of the CPU.

I/O bus structure: The communication of information to and from the computer, and from one computer component to another, is done via a set of connectors called a bus, the design of which varies from machine to machine. There has been some effort towards standards for bus design. A standard bus makes it possible to interchange electronic components such as memory boards and other modules available from many manufacturers. Many microcomputer systems have adopted a design known as the S-100 bus, and another standard bus used is the IEEE-488 bus. Most small computers have only one single channel available for data transfer as opposed to mainframes which usually have several channels operating in parallel. Consequently, data transfer is slower on small computers and many heavy-duty input/output applications (such as maintenance of an

online catalogue) are too slow to be effective.

e. Applications characteristics

The particular application or applications for which the minicomputer is required to serve are important for the selection of appropriate equipment. If sorting and searching operations are to be performed frequently, then sufficient memory must be available to manipulate the files. Controlled vocabulary searching is considerably simpler and requires less memory than free-text searching and character string searching is much easier to implement than Boolean logic.

Some applications require special input/output equipment such as light pens, touch terminals and badge readers. Local or remote access may be desirable. Response times may be crucial. Another critical factor in equipment selection is reliability and sometimes backup systems are required to take over operation should one system fail.

f. Interfaces to other systems

Computers can interface to other systems either directly (on-line interface) via a telecommunications link (or a direct hardware link if the two processors are sufficiently close to each other), or via a transporting medium such as punched cards, magnetic tape, floppy disk, and so on.

Systems can link with other systems in networks of various configurations. In distributed processing, systems can share tasks, data and resources through a network. It is in this mode of operation that minicomputers can easily compete with large centralised systems. The advantage of distributed processing over centralised processing is that operations do not cease when a processor in the network or one of the communications links fails.

g. Software

Particular attention should be paid to the availability of software. Editors are fairly standard on most systems but tney range from the unsophisticated line editor, which allows the user to add, delete or modify whole lines at a time, to complex text editors which allow the user to manipulate characters, strings of characters, whole lines, or blocks of lines interactively using cursor control.

Some manufacturers provide programs for basic file management - creating, manipulating, correcting, adding to, deleting from and retrieving from files. The most sophisticated file management packages are known as database management systems (DBMS's). These tend to be used for applications requiring many files of varying structures and having large numbers of users. They require large memory sizes and are, therefore, not available for the

smaller microcomputers.

The languages available for writing applications programs may be an important selection factor, particularly if considered in conjunction with likely training requirements and the availability of "off-the-shelf" software. The most common languages for minicomputers tend to be BASIC, COBOL, RPG, FORTRAN and, increasingly, PASCAL.

Some of the characteristics of systems used for minicomputer selection described above are difficult to quantify. How is one to judge system reliability, response time, peak activity loads, manufacturer support, for example? One way to arrive at quantitative estimates of these factors is to contact organisations who have similar equipment installed, especially those who have similar applications. Talking with users of systems can give some insight into how easy the system is to use, and what skills and training are required.

CHAPTER IV

APPLICATIONS OF MINIS AND MICROS TO INFORMATION HANDLING

With the rapid development of microelectronic technologies and the subsequent falling costs of hardware, a considerable amount of computing power is now within reach of many organisations previously unable to afford equipment. The increase in performance and reliability and the fall in costs have resulted in a tremendous surge of activity in applying the new technology to information handling procedures.

The areas where computers have traditionally been applied in information handling are:

- cataloguing
- circulation
- serials control
- acquisitions
- information retrieval
- management
- communications.

Originally, these systems were handled by large scale computers but in the 1970's minicomputers appeared on the scene and began to replace the larger machines. Minicomputers had a number of advantages. They were smaller, cheaper, more reliable and did not require a carefully controlled operational environment.

The use of minicomputers in information handling has been extensively documented, most recently by Grosch[3] who presents a survey of installed systems and discusses alternative system configurations and by Young[9] who analysed the selection criteria and use of minicomputers in federal libraries of the U.S.A.

In choosing the hardware for a minicomputer system, the library has a choice of three basic configurations: a dedicated stand-alone system, a front-end minicomputer connected to a large host computer, or a multiple minicomputer network system. In each of these cases the opportunity for growth exists by the addition of communication links with other computers. The simplest format is the stand-alone system dedicated to acquisitions, cataloguing, circulation or some other function. Even these may be tied to a larger network, such as OCLC, for cataloguing.

Minicomputer systems were initially viewed as "assistants" for a conventional large computer, being more like intelligent terminals to release the host computer from simple or routine chores. In some respects the minicomputer may serve a batch processing main computer by storing up transactions and then transmitting them for processing to the host, which can then return the results to the minicomputer for output. Virtually any present library computer application performed on a large shared computer may be enhanced in many ways by using an intervening minicomputer.

A network of minicomputers allows a large library with many branches to build its own internal network as powerful as those handled by large scale computer installations. Moreover, such a network may have considerable flexibility and can be designed to grow in both functional areas as well as capacity as the library gains experience and confidence with each step, and as the library's needs expand.

Microcomputers are relative newcomers to information handling applications but their potential in this area is considerable and a number of projects are already in progress. One of the major factors contributing to the development of microcomputer applications has been the growth of the personal computer market. The fundamental distinction between a personal computer and a microcomputer is one of marketing strategy - the personal computer is aimed at the hobbyist and the microcomputer at the small business or organisation.

Much of the microcomputer work in information handling was initiated in the late 1970's by extending the application of previously acquired word-processing equipment to simple text storage and retrieval. Word-processors are special purpose microcomputers dedicated to a single function - the processing of text.

The first major development in word-processing came in 1964 with the announcement by IBM of their Magnetic Tape Selected Typewriter Mark I. This was an automatic typewriter incorporating a magnetic memory. Shortly afterwards, the MTST was upgraded to include a second memory so that the system became more flexible. It was now possible to read a previously input text from one memory,

edit it from the keyboard and produce the final, corrected text, on the second memory.

The next major step in the evolution of word-processing systems was the introduction of visual display units (VDU's) so that the operator could actually view the final text as it was being produced. The VDU's originally only displayed half of an A4 page of text (11 3/4 X 8 1/4 inches), but, more recently, full page displays became available.

Developments in word-processing equipment proceeded in parallel with developments in computing technology. By 1966 electronic memories were being incorporated into various systems. The first commercially available word-processor with a large electronic memory was the Autoscribe, produced by Lexitron in the U.S.A.. Today's systems are much more sophisticated with features like shared logic, user programming facilities, communications capabilities and file protection.

In a paper presented at the 7th Cranfield International Conference on Mechanised Information Storage and Retrieval Systems in July 1979, Whitehead [1] described the development of word-processing systems and their application to information handling. He outlined areas where word-processors could be of benefit to information workers as follows:

i) Library catalogues - access by author, title or subject and automatic production of book lists by author, subject, date of acquisition, etc.

ii) Order processing - constant check of items outstanding is available and the equipment will produce standard letters requesting progress on orders

iii) Abstracting and indexing bulletins - input of bibliographical information which can be stored, sorted and printed in any sequence

iv) On-line searching - internal and external data base access using the word-processors as computer terminals ; storage and editing of input as required

v) Communications - word-processor to word-processor communications providing electronic mail facilities and offsite access to the data stores

vi) Borrower records - global search and select update facilities will provide up-to-date record of all loans and borrowers

vii) Periodicals acquisition - provision of constant check on periodical acquisition and location of each issue in circulation.

Over the period September 1979 to May 1980 data were collected on existing, operational minicomputer and microcomputer applications (including word-processor and personal computer applications) in information handling. The number and type of projects are constantly increasing, so examples have been selected for inclusion in this report rather than a comprehensive set of application descriptions. The examples below were those applications which were either documented or which were reported to the author through private communication.

Minicomputers in libraries and information centres

There are two main ways in which minicomputer-based systems are being used in libraries. The most widespread way, until recently, was in a turnkey system. This type of approach delivers a relatively simple machine that can handle standard clerical functions in circulation control, acquisitions and technical processing. Little technical skill is required of the library staff to operate the system and it is unlikely that the library staff would develop new software for their own use. These turnkey systems are complementary to network services and can be combined with the cataloguing and machine data base searching networks to create a very effective and economical "total" system for an individual library.

The alternative approach involves using minicomputers to provide an in-the-library computing facility. In such an approach the minicomputer serves as a replacement for the large scale computer traditionally used in system development and operation. Minicomputer-based facilities were considerably less expensive than large mainframes,and large libraries could afford one and therefore avoid the problems and conflicts experienced when sharing computer resources with others.

a. Commercially available systems

Minicomputers made their first appearance in libraries in support of the circulation control function. Computer Library Services, Inc. (CLSI) in the U.S.A., offers the LIBS 100 minicomputer-based turnkey system. Most installations of LIBS 100 have been limited to the circulation control function, but additional software modules are available to support acquisitions, accounting, cataloguing and film booking. The LIBS 100 system is sold as a complete package comprising a minicomputer, peripheral equipment such as disk storage unit, printer and several video display terminals as well as all the software necessary in order to perform specific library functions on a production basis.

Plessey Corporation (USA) markets a turnkey circulation control system which is more of a data collection device rather than a stand-alone package. Circulation transaction data has to be transmitted to a larger computer for processing and for preparing listings of loans. The Library Pen System consists of a

minicomputer, an optical scanning wand (for reading bar-coded labels), a keyboard terminal and some on-line storage.

In the United Kingdom, Libra Information Systems Ltd. developed the CAIRS (Computer Assisted Information Retrieval Systems) retrieval package for use by the Leatherhead Food Research Association. CAIRS is an on-line current and retrospective document search and retrieval system capable of storing 100,000 references online. It uses Texas Instrument mini and micro computers in its various versions, and is sold as a turnkey product. This includes a choice of hardware appropriate to the size of the installation and all software necessary to begin actual use of the system by a library. The following functions are available in each version: data entry, inverted file subject searching, author searching, accession number location, document or file searching, two library acquisition list outputs and complete file listings, key word index listings, SDI processing, serial character string searching and full record editing/updating. This system appears to be well designed and affordable for automation of bibliographic retrieval functions for special libraries having patents, reports, reprints, in-house documents or records to access.

A second British system, ADLIB, is designed with the special library and information centre in mind. It is offered both as a turnkey product and as a timesharing service by Lipman Management Resources Ltd. Thus, very small to large diversified libraries can use this system in whichever way would be more cost-effective for their individual file sizes and transaction volumes. ADLIB (Adaptive Management System for Special Libraries and Information Bureaux) can store full or partial bibliographic records for monograph, report, preprint, serial or audio-visual materials. Online thesaurus maintenance and the ability to accept British MARC format data are system features that enhance the utility of the system for a number of libraries. Circulation control is also handled by the system via data entry from VDU's. Output can be routed to a line printer or to magnetic tape for subsequent COM processing for micrographic catalogues. The hardware supporting ADLIB is a PRIME 300 with a minimum of 128K bytes of memory.

Another commercial system is the VUBIS system jointly developed by the Free University of Brussels and Interactive Systems, N.V.S.A., also in Brussels. This system uses the Digital Equipment PDP 11 minicomputers. The system software is based on the MUMPS (Massachusetts General Hospital Utility Multi-Programming System) operating system, data management system and application programming language. VUBIS is an interactive cataloguing input and public catalogue inquiry system which is eventually to have a circulation control subsystem, acquisitions and serials check-in. A key feature of the system is multiple language interaction. Users may interrogate the system in French, Flemish or English. Interactive Systems

plans to add a German facility also. A second unique feature of this system is in its subject access method. Keywords are assigned within the Universal Decimal Classification (UDC) scheme so that one may search by keyword tied to UDC numbers which can then be used to locate materials on the shelves. One can also search directly by UDC number. Such a system is particularly appropriate for libraries already employing the UDC scheme.

b. Non-commercial and semi-commercial systems

As early as 1973, the University of Sidney (Australia) Fisher Library was planning to employ an on-line minicomputer system for circulation control, with later enhancements planned to add other bibliographic processing capabilities. The system ran on a Data General Nova 840 and Nova 1200 system with eight LIBRAMATIC light pen terminals as well as portable light pen terminals for stock inventory use. A similar system using a Varian 72 minicomputer was installed at the University of Queensland. At the University of New South Wales Library, a DEC PDP 11/40 operating under the UNIX operating system (developed at Bell Laboratories) is used for the cataloguing system. Five VDU's provide data entry to the system, with additional applications planned over the next few years. Another system for cataloguing is installed at the Australian National University, which uses an Interdata 8/32. Its processor is equipped with a very large main memory which will undoubtedly support many other applications. A cataloguing system with book fund accounting and order writing is operational at La Trobe University Library (Australia) and runs on a DEC PDP 11/34 using the RSTS/E operating system and implemented in FORTRAN. Both book and card form catalogue production is supported via this system. In development is an acquisitions system.

The International Development Research Centre (IDRC), Ottawa, Canada has recently developed the MINISIS software (based on the ISIS system (Integrated Set of Information Systems) which was originally developed by the International Labour Organisation (ILO) and improved by Unesco) to run on a Hewlett-Packard 3000 minicomputer. The key design principles were: general applicability, modularity, independence, user considerations, mission orientation, capacity to accept outputs from other systems, viability within a small organisation, and compatibility with other international systems, e.g., AGRIS, INIS. A relational data model was chosen for the system and all programs were written in SPL, the HP-3000 system language. Initially intended to maintain the IDRC library's records, a database of over 20,000 records representing both monograph holdings and analytics, and a serials database of some 3000 records. Also there are about 4000 records representing items on order or awaiting cataloguing. Records are written in English, French or Spanish (the three working languages of IDRC) according to the language of the source document. Subject access to the collection is via on-line searching of descriptors assigned to each item from the IDRC's

trilingual version of the Macrothesaurus (OECD 1972). The library database is completely integrated but retains three "user views", such that the acquisitions librarian sees only those fields that relate to ordering plus a few selected bibliographic fields, and the cataloguer sees all bibliographic fields but none of the fields related to ordering.

In addition to the library database, the new MINISIS system is also used to produce Devindex Canada, an abstract bulletin of Canadian literature on the subject of development, from the DEVISIS (Development Science Information System) database. Another database run on MINISIS is SALUS which contains information about low-cost rural health care and health manpower training. The system has been made available by IDRC to 18 institutions, including 9 in developing countries. The ILO, FAO (AGRIS) and UNIDO databases have been converted successfully to be accessed on-line. It is estimated that acquisition of equipment for such a system would cost between 150,000 U.S. dollars and 200,000 U.S. dollars depending on the amount of memory, number of disks and number of terminals.

The University of Guelph (Canada) Library system, having had a number of problems using the Universities of Ontario's network, decided to acquire an in-house minicomputer. A GEAC 8000 with 256 K bytes of main memory was selected together with two 300 M byte disk drives and 16 communication ports. A backup capability was also acquired comprising a GEAC 800 minicomputer with 64 K bytes, 55 M byte disk and 8 communication ports. The total cost for this configuration was less than the cost of the University of Guelph's two-year participation in the Universities of Ontario network projects. The use of the GEAC computer meant that Guelph staff had to be involved in the system design. A number of modules are operational - circulation and cataloguing enquiry, and acquisitions. The next phase involves conversion of the catalogue and serials systems to on-line mode. Another area for development is the establishing of regional networks. The nearby University of Waterloo also has a GEAC minicomputer and circulation system similar to Guelph, although it was designed to meet their specifically defined local requirements. Both libraries are actively working toward a hard communication link between the two library systems using the technique of packet-switching.

Small scale computer systems have been used to aid catalogue production and maintenance. The University of Toronto Library Automation System's (UTLAS) Cataloguing Support System (CATSS) library network consists of a distributed network of minicomputers (Data General and Honeywell), around a large host computer (Sigma 9), which are linked to a number of microprocessor controlled transaction terminals. The system produces microform, book and card catalogues and supports its collection, inquiry, reporting and communications (CIRC) systems. The terminals handle basic housekeeping and line protocols. Future developments will include the addition of editing and request

processing to transaction terminals as well as computer-output-microfilm (COM) production and xerographic printing.

Minicomputers can be used to generate and manipulate special character sets. An example is the Chinese character processing system used by the Institute of Scientific and Technical Information of China (ISTIC) based on a TK 70 minicomputer with 65 K bytes of memory. This system performs the typesetting and printing of bibliographies, indexes and bulletins, in Chinese, of the ISTIC library. The Chinese characters are generated from a random access memory (RAM) of over 6,000 Chinese characters. The minicomputer is currently used for the following operations:

Printing of Chinese publications. The system typesets and prints bibliographies, indexes and bulletins produced by the library. The original manuscript is converted into paper tape or cassette tape format using a Chinese character keyboard and read into the TK 70 for editing and typesetting. When these operations have been completed a magnetic tape is produced which is sent to the T 4100 Chinese character printing system. Graphic information about Chinese characters is retrieved from the character generator using the codes recorded on the magnetic tape, and the printer prints out Chinese text. This output serves as a master for offset printing or photo-typesetting.

Machine translation. This system is also employed in experiments for machine translation of titles and full text of documents from English into Chinese.

Information retrieval. Several information retrieval programs have been developed on the minicomputer system. For example, one program is used to create and maintain a data file of documents concerning standards. Another is used to process magnetic tapes of foreign bibliographic material. Both of the above programs run in batch mode only. Some experimental work is underway to produce on-line retrieval software, but is not yet complete.

Establishment of Chinese bibliographic database. Computerised Chinese document retrieval, either on-line or off-line, could not be carried out until a certain pool of machine-readable Chinese bibliographic data accumulated. Now such a pool is ready and the creation of a Chinese bibliographic database is underway.

The ISTIC minicomputer system has been developed with a view to pave the way for the establishment of a centralised on-line retrieval system with a large computer, rather than itself being a long term solution to computerised information services.

A joint German-Israeli R&D project was set up in 1977 to develop a minicomputer-based information handling system with an

online interactive retrieval module and a batch mode input module. The project is known as DOMESTIC (Development of Minicomputer Applications in an Environment of Scientific and Technological Information Centers). Eventually the system will provide a tool for accomplishing the following objectives:

- database creation, update and management
- information storage and retrieval
- reference and referral services
- library management tasks
- information centre administration
- information networking.

Based on a DEC PDP 11/70 minicomputer installed at the National Center of Scientific and Technological Information (COSTI) in Tel Aviv, Israel, the system DOMESTIC I supports off-line database creation but enables interactive maintenance and retrieval. Under development are an on-line input module, a print generator, a function dealing with the data processing applications of special libraries and a thesaurus creation and maintenance function. One of the most interesting aspects of this project is the parallel development of software in Israel (on PDP 11/70) and Germany (on Philips 857 by KTS-Informations System GmbH, Munich) to produce a information system package which is portable on these two types of equipment.

In addition to the development of DOMESTIC, the PDP 11/70 at COSTI is used for a variety of applications including:

a) SDI services from commercial databases
b) On-line profile creation and maintenance
c) Maintenance of the Israeli register of on-going R&D
d) Maintenance of a number of databases and generation of a variety of directories for photocomposed publications (e.g., directory of research institutes, directory of special libraries, directory of irrigation equipment manufacturers)
e) Maintenance of the document collection of the Israeli Environmental Protection Service
f) Administration of applications for government grants supporting research and development.

The Gunma University Library, in Maebashi, Japan, uses an Okitac-4500C minicomputer in a small single user configuration serving a library with 300,000 volumes and annual serials subscriptions of 6,000 titles. This installation displays a departure from the current trend of online processing by using batch processing for acquisition, accounting, cataloguing and serials control functions. The single terminal is used for an online circulation system. Thus two jobs, one real time and the other batch, can be serviced at the same time in what is known as a multi-processing system.

In Sweden, the LIBRIS (Library Information System) uses a minicomputer as a front-end processor to switch users into one of four databases served by the system in accordance with users' requests. In May 1978 a minicomputer (PDP 11/34) with two disk drives was installed at the Royal Institute of Technology Library (RITL), Stockholm, Sweden. One of the first development projects was the design and implementation of a management system for periodicals control.

In Switzerland, the Hauptbibliothek der Universität Zürich-Irchel has installed a system supplied by Interdata AG which is used for acquisitions, cataloguing data entry and bibliographic file maintenance. It uses a minicomputer by Interdata which is built around an Intel 8080 microprocessor. The software is called TEX 400 and is a preprocessing system essentially for data entry.

The STATUS II system developed by the United Kingdom Atomic Energy Authority is used to produce abstract bulletins or published indexes from relatively large bibliographic databases. STATUS II runs on a PRIME 300 minicomputer under the PRIMOS operating system. Online the system may be used for retrospective searching and entry of bibliographic data or production of current awareness output based on user interest profiles. The system also produces magnetic tapes of indexes in various forms for computerised photocomposition.

Minicomputers also contribute to the development of library networking. The New England Library Information Network (NELINET), U.S.A., uses a DEC PDP 11/10 as a concentrator to reduce telecommunications costs in transmitting or receiving data from the Ohio College Library Center (OCLC). The BIBNET system of the Information Dynamics Corporation is similar in concept to the OCLC cataloguing network but is based on a different approach. Rather than communicate with a central computer to build or modify a catalogue record, a user of BIBNET can request that the record to be used be transmitted to the minicomputer, thereby reducing communications costs.

The Lister Hill National Center for Biomedical Communications (U.S.A.) has several projects related to the application of mini- and microcomputers to information handling. One major project is the Integrated Library System (ILS). The system is designed in a modular fashion and currently comprises the following subsystems:

- Master bibliographic file and bibliographic control
- Circulation subsystem
- Public catalogue access
- Serials check-in
- Administrative subsystem.

Future enhancements planned include full serials control, acquisitions, enhanced cataloguing capabilities, and a generalised network access module. The ILS software is designed to operate on PDP 11's, Data

General's Eclipse series, and IBM Series /1 minicomputers. It operates under the Meditech Interpretive Information System (MIIS) using a version of the MUMPS language. While ILS can be implemented on a computer costing as little as 25,000 U.S. dollars, a medium-sized library may require a configuration costing 50,000 U.S. dollars or more. Other costs associated with installing ILS include those for the MIIS operating system, facility preparation, supplies and any software enhancements and maintenance. The ILS software itself is available from the National Technical Information Service (NTIS) for 2,000 U.S. dollars.

The U.S. Department of Agriculture, Science and Education Administration, Technical Information Systems (TIS), is using minicomputers primarily as a data entry tool. The AGRICOLA database is prepared using a Four Phase minicomputer data entry system. There are 18 VDU terminals connected to the minicomputer through which indexers enter descriptive records of journal articles which are then stored on magnetic disk. Once a week, the records on disk are transferred to magnetic tape and entered into the database (which is currently maintained on an IBM 370 computer system). The Current Research Information System (CRIS) is another database that is maintained by TIS. In this case, a Data Point minicomputer is being used for data entry. Transactions are entered from VDU's and stored on disk. Periodically, the batches of transactions are transmitted from the Data Point system to the Washington Computer Center where the updating of the CRIS file takes place on an IBM 370. An on-line version of the CRIS file is also maintained by Lockheed Information Systems.

Fairly complex data management systems are available today on mini- and microcomputers. One example is a system developed at the Pikes Peak Library District (U.S.A.) which is based on a PDP 11/70 minicomputer with 500 K bytes of memory. The system holds information for the management of materials held by the Library District and details of registered patrons (over 80,000). The system operates at three levels: library resources, community resources, and state and national resources, and is accessible by both patrons and staff.

i) Library resources

A complete file is held of all the card holders of the Pikes Peak library. Programs allow users to check out materials, to see which items are checked out by users, to make reservations. Other files include a file of all materials at the main library and at branch libraries, and a file of all old and current periodicals held.

ii) Community resources

The Community Education and Recreation Center Index (CERCI) was designed by the Pikes Peak Library to provide information about educational and recreational opportunities in the district. Details are available on local clubs, job opportunities, training programmes, college courses, financial aids, occupations, day care centres, car pools and much more.

iii) National resources

The library provides users with access to national information resources such as Bibliographic Retrieval Services (BRS), Lockheed Information Systems (Dialog), System Development Corporation (ORBIT). The Research Libraries Information Network (RLIN) is used as a cataloguing tool - the RLIN database is checked before an item is catalogued to see if an entry exists for that item. If so, the record can be transmitted to the Pikes Peak system and modified for in-house use.

iv) Administration

The data management system provides a large amount of management data as a by-product of its normal operations. Budgets are planned and accounts maintained through the system. Personnel files are kept and are being interfaced to a payroll program.

A much smaller system was developed by the Primate Research Center at the University of Washington (USA) on a Prime 300 minicomputer. The Primate Information Center builds and maintains a bibliographic database of more than 25,000 extensively indexed citations, which is used to produce Current Primate References (a monthly listing of titles with subject headings and a primate index), a series of printed bibliographies on selected topics in primate research (with subject and primate indexes as appropriate), custom retrospective bibliographies and custom bi-weekly bibliographies.

The same minicomputer system simultaneously supports another information system which uses database management. The database contains medical histories, breeding records, colony management information and accounting data for all monkeys held in the Regional Research Center's three geographically separate colonies. The average monthly inventory is over 1500 animals. Data entry from all three colonies is on-line and interactive. The database is searched on-line and printed summaries are produced regularly.

c. Minicomputers for Personal Information Handling

Minicomputer systems have proven to be competent in handling personal and group files. Parker and Thorpe[12] describe GRIP (General Retrieval of Information Program), a system based on Hewlett-Packard 2100S and 21MX(E) minicomputers. This system was designed to be flexible for handling small files of less than 200,000 characters which are typical of personal and departmental files. Leggate and co-workers[13] studied the suitability of minicomputers for handling personal databases. Their experimental system ran on a PDP 11/20 minicomputer with 12 K words (16 bits per word) of main memory, 2.4 M bytes of disk storage and tape storage - a fairly small minicomputer by today's standards.

Pathfinder I is a minicomputer-based system developed by the Intelligence System Staff, U.S. Drug Enforcement Administration[14]. It provides a wide range of sophisticated searching capabilities. The system runs on PDP series (11/45 or 11/70) minicomputers. Bell and Jones[15] describe MORPHS (Minicomputer Operated Retrieval Partially Heuristic System). This system uses linguistic algorithms for finding word roots, and handling synonyms and compound words. It runs on a Varian 620 with 32 K bytes of memory, although it is capable of running in 12 K bytes. The AMP Inc., information centre has developed an information retrieval system which runs on a Prime minicomputer[16]. This system allows natural language searching, word truncation, adjacency and pattern matching, searching of all special fields, and convenient display control. User aids are provided in the form of online instructions, term frequency lists, a vocabulary guide, and preconstructed strategies.

Lundeen has developed a minicomputer-based information handling system, known as FUINUI, for the input, editing and maintenance, and online searching of local databases[17]. It operates much like the commercial online services in its use of Boolean operators, comparison searching, free text search capabilities and formatting of output. Though originally designed for teaching the basic concepts of online searching, the system is finding other uses as well, such as student placement file, bibliographic production, reserve book file. The system is written in BASIC and runs in a region of about 10 K (16 bit words) on the University of Hawaii's Hewlett-Packard 2000 minicomputer. The system is capable of handling a variety of record formats. The largest file thus far is about 200,000 characters.

These examples of viable, minicomputer-based systems would suggest that the microcomputers now available or soon to be available at a low cost would be capable of handling these tasks. The power of the new 16-bit microprocessors is approaching that of the low to medium end of the minicomputer spectrum.

Microcomputers in libraries and information centres

Although they have only been available over the last few years, microcomputers are finding uses in almost all functional divisions in libraries. A number of projects are in progress but very few of them have been formally documented. At the recent ALA (American Library Association) meeting in San Francisco (June 1981) a number of commercially available microcomputer-based library application packages were announced.

a. Commercially available systems

The MINI-MARC system of Informatics Inc. uses a 16-bit microcomputer (Computer Automation LSI-220) with floppy disk storage. The system provides full MARC bibliographic records with a database consisting of 500 floppy disks. Records can be displayed, modified, and transferred to a blank floppy disk to build custom catalogues. This system has been used to produce abbreviated catalogue records for use with a CLSI LIBS 100 circulation system. The system costs about 50,000 U.S. dollars.

Futura Computer Products Inc. have produced a microcomputer-based circulation system. The system is designed for easy use with screen prompts. A bar code wand captures patron identification and the code is then displayed for confirmation. A manual override option is also available. Futura will write custom overdue and recall notices as well as various management reports. The Futura Library Circulation System has been written using the latest version of the CP/M operating system by Digital Research. As new releases of CP/M become available, Futura will be in a position to upgrade the system. Three system sizes are currently available with 5 inch, 8 inch or hard disk storage. The system costs about 15,000 U.S. dollars at the lower end and about 30,000 U.S. dollars at the top end of the range. Ringgold Management Systems Inc. have produced the Nonesuch Circulation System which has been implemented to operate on a wide range of computers, from mainframe to microcomputer. The system was designed and developed by librarians and retains the characteristics of simplicity, reliability and low cost. All software is written in COBOL. The current configuration consists of a 64 K byte microcomputer with a hard (10 M byte) disk and floppy disks (700 K byte). This configuration is capable of controlling approximately 50,000 titles and patrons and costs 29,000 U.S. dollars.

CTI has produced two microcomputer-based library packages. They run on either an Apple II or the more sophisticated Microdata computer. The package contains the following functional modules: total circulation, catalogue production, keyword title search, acquisition, audio visual booking and serials control.

b. Non-commercial systems

As details of microcomputer-based projects were accumulating, a pattern of microcomputer use began to emerge, bearing considerable resemblance to Whitehead's list of applications, as follows:

- catalogue production
- bulletin production
- circulation
- acquisitions and serials
- reference and data management systems
- administration
- online searching
- communications
- education and training

Illustrative examples of each of the above category have been selected and the following descriptions are by no means comprehensive.

i) Catalogue production

A word-processor (BDP 90-02) has been used successfully at the South East Thames Regional Library and Information Service (SETRLIS), a co-operative of fourteen libraries, for catalogue card production. When a new book is ordered by one of the libraries, a check is made to see if it has already been recorded in the word-processor and stored on floppy disk. Each disk holds about 250 titles. Details of books acquired by member libraries are submitted to the main centre and entered into the system which manipulates the records to automatically produce the required number of catalogue cards in the desired format.

On a smaller scale, the Glendora (California) Public Library is using a Radio Shack TRS-80 to enter cataloguing-in-progress (CIP) data for the production of catalogue cards. It is reported to be using the system to keep track of book orders and plans to add a circulation overdue system.

ii) Bulletin production

Abstracting and indexing bulletins have been produced on minicomputers for some while now, but today low cost microcomputers are achieving the same results. The facilities available on such systems include: input, editing, sorting, searching, index card production, generation of special topic bulletins, monthly updates, cumulations and output formatting.

The Information Services Division of the University of Tulsa (U.S.A.) uses a 32 K byte Altair 8800b microcomputer to input, edit and print the bulletin "Petroleum Abstracts". The Editorial Processing System (EPS) is a microcomputer system that combines word processing and data processing. Once the bulletin entries

are input to the system they can be used for the generation of author indexes and bibliographic lists, and the records are transmitted to the University's full scale computer for archival storage and retrospective retrieval. Before this system was introduced, the bulletin was manually typed on variable-spacing typewriters. With such a process the abstracts were retyped at least once before finally appearing in the bulletin. They also had to be sorted by hand for inclusion in the bulletin.

The implementation of the system at the start of 1978 revealed a number of initial problems (such as the effect of static discharges and power fluctuations). These were solved readily without causing delays in the production schedule. The most serious failures were due to unfamiliarity of personnel with the operating procedures. The final system configuration consisted of two Altair 8800b micros each with 48 K bytes of main memory, two Altair 300 K byte floppy disk drives, two Diabolo printers and two Data General 6053 terminals. The total cost of hardware and software was in the region of 30,000 U.S. dollars.

A similar system has been developed by the American Geological Institute. The GeoRef database is maintained through their input and edit system which runs on a Datapoint 6600. Fourteen display terminals are linked to the system and input is achieved using 28 pre-formatted screens, verification of index terms, and online look-up of serials titles and extensive error checks.

A system of particular interest because of its special character handling capability is the Vydek 1400 word-processor used by the Pharmaceuticals Division of the Imperial Chemical Industries (ICI), United Kingdom. Vydek, in conjunction with ICI, has developed a system for handling complex chemical structures on the word-processor[18]. On it, commonly used structures, such as the benzene ring, can be stored in memory and recalled by the operator as required. Other complex structures can be built up, one bond at a time. This means that mixtures of text and chemical structure representations can be stored, printed and transmitted to compatible systems.

iii) Circulation

The Oakridge (Oregon, U.S.A.) Public Library reports the use of a low cost (under 3,000 U.S. dollars) 8-bit microcomputer (Ohio Scientific, Inc. C2-8PDF) for a circulation system. This illustrates one area of future impact for microcomputers in libraries, particularly for small libraries.

Another circulation system using a microcomputer has been developed by Cincinnati Electronics Corporation. This is a stand-alone system that operates in an online interactive mode. This system, like the one at Oakridge, is an absence file or transaction recording system (only items that are issued are kept in the computer file) that requires much less storage than an inventory system.

Microcomputers can also be used as front end interfaces between the librarian or user and a large computer system. The Decicom, Inc. circulation system developed for the Nassau County (New York, U.S.A.) Public Libraries is an example of this approach. A 16-bit micro is used in this system and transactions are stored on tape for batch processing on a mainframe.

iv) Acquisitions and Serials

One example of a microcomputer being used for acquisitions work is the TRS-80 system that keeps track of book orders at Glendora Public Library (see section on catalogue production).

The problem of serials control is complex but some microcomputer-based solutions are beginning to appear. G. Lundeen of the Graduate School of Library Studies at the University of Hawaii has written a journal routing slip program that runs on a Radio Shack TRS-80 Model I.

CLASS (California Library Automation Systems and Services) also uses a TRS-80 Model II microcomputer for its serials control system, Checkmate. The system functions include check-in, claiming, routing, accounting, production of title and subject lists and subscription expiration alert reports. Special features of the system include:

- keyword searching using Boolean operators
- sophisticated command language and field modification techniques
- flexibility to accommodate individual needs
- variable length records
- automatic file scan to locate late or missing issues
- prompted data entry
- user-selectable record printing formats
- user-defined indexing
- built-in stop word list which is user modifiable
- MARC-like or user-defined field tags
- addition and deletion of temporary notes to any field
- file security

Currently using floppy disks, the system provides access to 2,000 records. However, future development of the system will incorporate a hard disk capability which is planned to support up to 6,000 records.

v) Reference and Data Management Systems

REFLES (Reference Librarian Enhancement Systems) is an online microcomputer-based system initially designed for handling in-house data files in a library reference department. The system, developed at the UCLA Graduate School of Library and Information Science (U.S.A.), is now a generalised prototype software package

housed in an inexpensive readily available microcomputer - the TRS-80. The system development philosophy was to enable the capturing of data which do not exist in printed sources, which are essentially inaccessible, and which are in need of frequent updating. In effect, REFLES functions as a "group scratch pad".

REFLES I was designed to be utilised in a library environment where it could enhance library reference service by providing quick, efficient, and relatively easy access to information and data stored in an in-house database. The major limitation of the system was the storage capacity of a single floppy disk (20 logical records of 40 lines of data). Consequently, REFLES I was adapted and modified to become a more generalised software package, REFLES 2, for the purpose of developing individualised databases in a number of environments. The adaptation is currently mounted on an Alpha Micro 100.

The University of North Carolina at Greensboro is using microcomputers in connection with the development of a Children's Media Database. Using a Processor Technology Sol 20 (costing about 3,500 U.S. dollars) with the ELECTRIC PENCIL text editor, lists of periodicals indexed by such basic access tools as Education Index, Current Index to Journals in Education, and Library Literature were keyboarded. Each list was then run through a program which posted an abbreviated code for the indexing service (EI, LL, CIJE) at the end of each citation. The three lists are then merged to eliminate duplicates. Then, additional occurrences of periodicals already in the database are noted, e.g., Social Science Citation Index, PAIS, Wilson Indexes, Psychological Abstracts, etc. The end result is the publication of a "Guide to Indexed Periodicals in Education".

A second project relating to the microcomputer is concerned with a table of contents service in criminal justice. A by-product of this project is the publication of an "International Guide to Periodicals in Criminal Justice" which is entirely microcomputer-produced and contains a list of indexing and abstracting services, a basic list of periodicals in alphabetical order, with periodicity, publisher information, and an indication of indexing and abstracting coverage.

vi) Administration

There are several microcomputer applications that would help in performing administrative functions, including word processing, reporting, and fund accounting.

Word processing packages for microcomputers are now available with fairly sophisticated capabilities. Those sell for about 100 to 200 U.S. dollars and allow editing, formatted printing, automatic page numbering, footnote and index generation, right

justified margins, and so on. The real appeal of these systems is the ease with which one can revise textual material once it has been typed. Changes are made very easily, and successive drafts can be produced automatically; only the alterations require manual input. Libraries produce many kinds of typewritten documents (correspondance, memos, reading lists and bibliographies, guides, etc.) that could be done with a word processing package running on a microcomputer with a good quality printing terminal.

vii) Online searching

All microcomputers with the standard RS 232 communications interface can be used as simple terminals to search remote databases using a telephone connection and a modem. This type of operation, however, does not fully exploit the potential of the microcomputer for retrieval. There are two ways that microcomputers can be used for online retrieval: as pre-processors and post-processors.

As pre-processors, microcomputers perform various operations prior to the user's interactions with a remote database. Today, there are vast numbers of machine-readable data bases available for online searching from many different vendors. Often, the command languages and the command syntaxes, although similar, differ from system to system (14). The various command sets and rules for using the systems could be stored in a microcomputer and recalled by the user immediately before going online. Long character sequences required for logging-in to various systems could be stored in the same way and initiated from a single function key on the keyboard to accomplish automatic logging-in. Complex search strategies which will be used frequently can be handled in a similar way.

As post-processors, microcomputers are used to manipulate records that have been retrieved from databases. Records can be reformatted and merged to produce reports. Indexes can be automatically generated from the retrieved record set. Bibliographic Retrieval Services (BRS) in Scotia, New York, have recently made a microcomputer-based terminals available to their users. This microcomputer, called the PDS I, is connected to the BRS computer system as though it were a "dumb" terminal. However, records that are retrieved from the database may be stored locally and re-accessed by the user.

viii) Communications

A number of computer networks are being developed for the microcomputer user:

Digicast, like teletext, will transmit words and pictures over broadcast waves in a steady stream. The Digicast transmission will include news, financial data, real estate listings,

classified advertisements, weather forecasts, computer programs and library resources. To receive the service, users need a modified personal computer with a radio receiver. As in teletext, the computer will "retrieve" only those items which it has been programmed to catch.

PCNET (Personal Computer Network) is an electronic mail system for Commodore PET personal computer users over telephone connections. To use the system PET owners need a modem and the PCNET programs (costing about 8 U.S. dollars).

The Source is the first home terminal consumer information network put on the market in the U.S.A., and probably the most ambitious. People with home terminals can call for specific information including any UPI article over the last 7 years (newspaper articles), computer programs, video games and airline information. In addition, the Source offers electronic mail to other terminals ,and for 75 U.S. cents a computer message becomes a telegram transmitted to O'Hare airport in Chicago. . All transmissions are over Telenet (a private data communications cable network), and service is limited to off-business hours and weekends when network charges are cheaper. To use the system a personal computer or data terminal plus modem and telephone connection are required, and the service costs 2.75 U.S. dollars per hour.

An alternative to broadcast media, the Community Memory Project was initiated in the San Francisco area for public management of public information. The system is a network of small computers with large memories, each connected to 10 or 20 computer terminals located in public places (such as libraries, shops, community centres, etc.). The network is used as an electronic bulletin board. The project is interesting in that it is one of the few systems that does not require people to own a terminal or microcomputer to use it.

ix) Education and Training

Probably the greatest potential use of small scale computing equipment is in education and training of library and information professionals, and of users of library and information services. A study of how a microcomputer could be used to instruct graduate students of Library and Information Science was carried out at the University of California, Berkeley in the Spring of 1980. The preliminary findings are presented here as an example of the potential impact of microcomputers in education and training.

Library instruction generally takes two forms - library orientation and formal instruction. The primary purpose of orientation is the introduction of a particular library and its resources to new users. It attempts to inform the user about location of materials and equipment, physical organisation and other facilities that are provided.

Formal instruction, on the other hand, consists of courses that offer instruction on information organisation, retrieval and management. Computer-aided instruction (CAI) can be used for both types of instruction. There are, in fact, many advantages to using CAI over tours, lectures, audiovisuals and other methods of instruction.

One great factor in favour of CAI is timing. Most orientation tours and courses occur at the beginning of the semester when there is an influx of new students. Unfortunately, that is a time when new students are bombarded with all kinds of information about their new environment. It is thus questionable whether the first week or so is a good time to conduct library orientation. New students would be able to absorb the information much more easily when they have settled in and when they begin to use the library. Motivation, an important element in determining the success of learning, would be higher at such times. With CAI the problem of timing is no longer relevant. The programs are always available for use by anyone who needs to learn about the library or its bibliographic tools. Moreover, the hours during which a student can get help in using the library are extended.

The advantage of CAI for library instruction also hold true for more formal instruction. A formal course teaching library use could be divided up and written as a number of separate programs (or modules) each on a different topic. Students could go to the program that answers their particular need. The incentive of needing to use the skills learned makes for faster and more effective learning.

As whole courses could be divided into different topics that can be accessed independently of each other, the depth of coverage could vary if CAI were used. Using CAI students get individual instruction in terms of the amount of time spent on each module (obviously, the content of the courses is essentially the same for all students). However, courses can be designed to operate in several modes, e.g., in varying amounts of detail - similar to the naive and experienced user modes of operation of some bibliographic retrieval services. Similarly, it is feasible to design different packages of instruction based on the same topic, bearing in mind the different backgrounds of the students. Students can choose the most appropriate courses for themselves.

Another advantage of CAI is that the student can work at his own speed. Those who learn quickly are not held back, while those who are slower can work at their own pace without feeling the pressure of trying to keep up with others. They can repeat courses as many times as required - computers never become impatient.

The learner can repeat until he is satisfied that he has understood what is being taught. At the same time, it is possible to have stricter control over the learning process in CAI by means of frequent tests. These would probably occur at the end of each module and would indicate whether the student is having any problems, and if so with which parts of the course. If the tests indicate that the student has a clear understanding of the material presented in the module then he will be allowed to continue. Otherwise the student may be "locked out" of the next module until he can perform satisfactorily in the test.

The microcomputer is particularly suited to CAI within the library. Library instruction programs do not require large volumes of storage space and therefore, the limited storage capacity of the smaller microcomputers is not important. As prices today start at a few hundred U.S. dollars for microcomputers (see Annex III) most small organisations can afford to invest in at least one.

The main disadvantage of CAI lies in the preparation of the courses. Much more care must be taken to ensure that there are no ambiguities or contradictions which could be queried in a conventional classroom situation, but would only confuse the learner using CAI. However, because they are stored in machine-readable form, the CAI courses can be distributed and shared by many organisations. If such co-operation were achieved then each co-operating organisation could prepare, for example, one course. If practised on a national or international scale the advantages of co-operative effort in the preparation of CAI modules would be considerable.

Although CAI does offer a number of advantages over conventional teaching methods, it is unlikely that CAI will replace them. The interaction between teacher and student is invaluable in the learning process and CAI cannot offer any alternative superior to that interaction. It is expected that CAI will be used in the future to complement existing teaching methods.

CHAPTER V

TRENDS AND FUTURE POTENTIAL

Technological innovations will inevitably lead to changes in the way we acquire, transmit and use information. Future changes will be caused by complex interaction between new technologies, new communications media and new concepts for dissemination of information. These, in turn, will affect education, working environments, and recreational activities. Meadow [19] predicts:

> "By the beginning of the next century we can expect: (1) a diminution of the importance of the printed word in favour of electronically distributed magnetic recordings; (2) a lessening of human effort in deciding what information to record and how; rather we will tend to record nearly everything and postpone until retrieval time the intellectual work of deciding what is important; (3) a smaller number of information depositories and a larger number of service institutions; (4) the disappearance of the scholarly journal as a bound, tangible entity, in favour of the 'journal' as a collection of independently published articles, individually distributed to consumers on demand; (5) electronic conferencing replacing many of today's face-to-face meetings".

Two different aspects of the future of information handling can be identified:

- further development of information systems
- effect of such development on information professionals.

Further development of computer hardware & information systems

The basic capability of the microcomputer is to process information, and it is to be expected that, at least initially, the innovative markets will be created by replacing existing information products with semiconductor equivalents with the same,

or improved, facilities. Advances with particular relevance to information handling are likely to occur in the following areas.

a. Processing

It is expected that the current trends in reduction of physical size and cost together with an accompanying increase in reliability and processing power will continue, although probably not at the same high rates.

b. Memories

All of the electronic memories described in Chapter II are random access devices. Substantial economies can be achieved if random access is not required. One alternative scheme already under development is serial access, in which the stored bits of information circulate as if they were in an enclosed pipeline.

Examples of electronic memory devices organised in this way are charge-coupled devices (CCD's) and magnetic bubble devices. Each bit that is stored is transferred sequentially through 64 or more storage locations between the time that it is written into the memory and the first time it becomes available for reading. The rate at which the bits are shifted from one storage location to the next in a CCD memory is about the same as the cycle time for a random access memory. There are several reasons why CCD memories can be designed to have a smaller total area per bit and potentially lower cost than random access semiconductor memories. First, the area required for an individual storage cell is smaller than for a RAM cell. Second, the amount of address decoding required in a serial memory is less than it is in a RAM since decoding to select individual locations is not required. Third, the charge representing the stored information is always conveyed and held on tiny intersections in the circuit.

The other form of microelectronic serial-access memory exploits the mobility of magnetic bubbles (domains of magnetic polarisation) in a thin magnetic film of orthoferrite or garnet. A key feature of bubble memories is that the stored information is retained when the external power is interrupted. The polarisation of the bubble is preserved by using a permanent magnet to maintain the steady magnetic field. Like CCD memories, bubble memories cannot compete with random access electronic memories in terms of speed. Their most attractive potential application is the replacement of tape and disk memories with a capacity of on-board storgae of between ten million and thousands of millions of bits.

A new type of moving-surface store is being developed which could have significant impact on the volumes of information available for on-line access. This new storage device is the optical disk. There are two approaches to recording on these disks. One is an analog method which yields a colour television

picture, and a digital method which stores data in digital form. It is the latter type, in particular, that could revolutionise information handling in the not too distant future. The current capacity of such disks is of the order of 10^{11} bits.

The disks can be written once only. A laser diode is used to burn away a thin metallic film from the disk surface to create a hole about one micrometer in size. The presence of a hole signifies a one, and the absence of a hole signifies a zero. The projected cost for the disk is 10 U.S. dollars and copies could be made for almost the same amount. Kubitz[2] estimates that a disk can store about 10,000 books (the full text) making the projected cost per book about 1 thousandth of a U.S. dollar. The bulk of the expenditure when using optical disks will be on the disk readers.

The application of microcomputers in libraries has not been as extensive as one might have expected. One major reason is that microcomputer systems have been rather limited in the amount of mass storage they could handle. Until recently, storage was limited to cassette tape or floppy disk . Floppy disks are available in two standard sizes (5¼ inch mini floppies and 8 inch disks). Storage densities are increasing, but single density capacities for these disks are about 90 K bytes and 250 K bytes per disk respectively, which is not sufficient for many library applications. Quadruple density mini disk and dual density 8 inch disk systems are currently available, and higher densities are predicted for the future.

A typical floppy disk based microcomputer system has a maximum capacity of about two million bytes. If each record could be 500 characters or under then such a system would have a capacity for storing 4,000 items. Shorter records (such as those that might be used in a circulation system) would increase the number of records that could be handled by such a system, but for many applications floppy disk storage is inadequate.

Hard disk systems have recently become available for interconnection with microcmputers, and more and better hard disk systems are being developed. These disk storage systems offer capacities of between 2 million and 150 million bytes per drive. Microcomputer systems with these storage units should be capable of handling most applications where small to medium sized minicomputers are currently being used. Once these high capacity storage systems become available at competitive prices, we can expect the number of microcomputer-based library applications to increase significantly.

c. Costs

The first commercial computer, the Univac I, cost about 1 million U.S. dollars in 1952. Today, a reasonable amount of computer power can be purchased for under 1,000 U.S. dollars. On the whole, the costs of computer hardware have been falling

by a factor of 100 each decade. However, the cost of the microprocessor is becomming a smaller and smaller percentage of the total computer system cost. Peripheral devices, such as terminals, printer, mass storage devices, are dropping in price also, but less rapidly than computers themselves.

Communications

Communications may be expected to play an increasingly central role in information handling. Satellite-based communications systems offer a different approach to the present ground-based systems in terms of technology, but the services offered by the two systems should be similar. Satellite communications will probably develop as an extension to the ground-based systems, and will provide a more cost-effective solution in sparsely populated areas, for example.

A considerable amount of growth is expected of digital communication over the standard voice communication channels. The future pattern of data communications is likely to be considerably different from today's pattern. The main loading can be expected to be generated by electronic mail, electronic funds transfer etc., and in general these services will be person to person (via an intermediary computer) or person to computer, rather than the computer to computer communications that predominate now.

Software trends

Another deterrent to widespread use of microcomputers in information handling activities is the lack of adequate software. Systems software includes operating systems and programming languages (assemblers, compilers, and interpreters). Operating systems for microcomputers have been fairly primitive when compared to those available on minicomputers. However, operating systems for microcomputers are becoming more sophisticated and more user-oriented. Also, multi-user operating systems are beginning to appear for micros, so that several users can access the computer simultaneously.

For many years the only choice in programming languages for microcomputers were BASIC and assembler. Within the past two years, many popular languages have become available, e.g. FORTRAN, COBOL, Pascal, FORTH, APL, PL/1, and LISP are all available. The usefulness of a computer language depends on particular features implemented, diagnostic aids, efficiency of the machine code produced etc..

Much of the applications software being marketed for micros is of mediocre quality, and is often very poorly documented. The information specialist eager to use a microcomputer in a documentation, library or archival application will usually have to write (or have written) the software for the job, although, as reported at the 1980 ASIS Midyear Preconference Workshop on Microcomputers in

Libraries, it is possible to adapt available software in some cases. The information specialist who is thinking of using microcomputers for some application should realise that the programming is not a trivial task. Software may well cost much more than the system hardware.

New services in libraries - computers as media

Computers and computer programs are new forms of library material, perhaps to be used and borrowed by the library patron. Many public and school libraries are acquiring low cost personal computers for use as educational and/or entertainment media. In addition to software available for computer games, computer-assisted-instruction is receiving much attention. School and public libraries will probably include educational and recreational programs in their collections, and librarians will need to know enough about this type of media to make decisions on acquisition and use.

Other information services

The range of information services that are amenable to electronic information handling is extensive. There are a number of broadcast or multiple-access services. The most obvious services are those which provide rapidly changing information which are of considerable economic value to the businessman. Some systems - airline reservations, stock exchange transactions and international monetary exchange rates - are already available. The second type of service will provide transient information, such as newspapers, consumer advice etc.. A third type of service will provide information that would be physically expensive to access and transport by other means e.g. books and library services.

Three types of electronic information service are already in operation. They are computer-based services, Videotex and teletext. These systems are considered as prototypes for information delivery systems of the future rather as a long-term solution.

Standards

The primary standards of the future will be, or will be related to, language standards. A tentative step towards language standardisation has been taken by the development of a common command set for Euronet-Diane (Direct Information Acces Network for Europe) services. Standards still need to be agreed for interconnection of microcomputers, for floppy disk transfer formats and for information handling procedures.

Effect of developments on information professionals

The most far-reaching effect of developments of new technologies on information professionals is in their education

and training. Barron and Curnow[20] state that:

> "a particularly serious barrier to the exploitation of microelectronics...is the lack of technical awareness and technical expertise, particularly about the microcomputer..."

Educators must now familiarise themselves with recent advances in technology and their likely impacts on information handling, in order that they may prepare programmes for the re-training of professionals and programmes for the education of the next generation of information professionals. The new technology itself can be used to aid the educators in the form of computer-aided-instruction packages which permit self-paced and decentralised instruction.

With increasing volumes of information being stored and transmitted in digital form, and access to the stores being effected increasingly from the home environment, attention must return to the traditional areas of information handling - organisation, classification, subject indexing. In sorting through large amounts of seemingly relevant retrieved material, users will want some sort of quality indicator attached to the information. It is envisaged, therefore, that in the near future, a number of investigations will be initiated to consider possible solutions to these problems.

CHAPTER VI

RECOMMENDATIONS

Action at the national and international levels

Recommendations for the application of minicomputers and microcomputers to information handling are made in three areas:

- further investigations
- education
- standards

a. Further investigations

In making recommendations on a methodology for the automation of information handling procedures using small-scale computing equipment, to the developing nations in particular, it is necessary to relate the information requirements of individual nations, and of institutions within those nations, to the availability and capability of hardware and software. Specifically, the following investigations are recommended:

i. Investigation into the information requirements of individual developing nations

ii. Comparative study of small-scale computing equipment, including assessments of reliability and manufacturer support

iii. Compilation of a directory of software packages specifically designed for information-handling applications.

b. Education

The greatest potential barrier to the efficient and effective

use of microcomputers is lack of technical awareness and technical expertise. It is necessary to create a programme to educate and inform information professionals about current developments and future potentials of the technology.

One of the serious limitations to the introduction of advanced technology into the developing countries has been the high purchase cost (often payable only in "hard" currencies). As the cost and availability of small-scale computing equipment is no longer prohibitive, the main obstacle to full exploitation of the technology is the lack of trained personnel. Such personnel have an important role in the identification of the information requirements of their individual nations and their education must be seen as the primary recommendation of this report.

c. Standards

It is in the interest of users that standards should be developed to ensure the most efficient utilisation of equipment, data and products. Recommendations are made for the derivation and evaluation of standards for the following areas:

i. hardware interconnection in small-scale equipment

ii. transportation of software on floppy disks

iii. documentation of systems.

Institutional level recommendations

At this level, recommendations are made concerning the selection and installation of small-scale computing equipment, evaluation of "off-the-shelf" software, and training of appropriate personnel.

The tremendous variety of equipment currently available, together with the almost overwhelming range of peripheral devices, cause serious problems in the selection of equipment appropriate to a particular application. Basically, equipment should be chosen according to its ability to perform the functions required of it within the organisation.

The general approach to equipment and configuration selection is documented in many books on systems analysis and design. Briefly, the major steps in the acquisitions process are:

- Identify and quantify (where possible) potential applications

- Rank applications and desired features in order of importance

- Collect data on the capabilities of various computer system hardware components

- Collect data on potentially applicable software

- Interact with other users of either the hardware or software under investigation

- Interact with other users having the same, or similar, applications (these users may, or may not, overlap with the users above).

- Evaluate equipment alternatives in terms of organisational and performance requirements and potential applications

- Develop an implementation plan

- Develop a training plan.

There are a number of significant limitations of small-scale computing equipment, particularly at the lower end of the scale, that should be taken into consideration whilst performing the above tasks. They are related to:

a. Storage

Microcomputers using floppy disk stores are fairly limited in their ability to process even medium-sized files. Applications which process large files should be run on systems incorporating hard (Winchester) disk technology.

b. Timesharing

Few microcomputers, at present, have the facility to support multi-user environments. If applications require several users to access the computer simultaneously, then a large micro or a minicomputer should be selected.

c. Operating environment

Minicomputer and microcomputer systems comprise the CPU, plus a range of peripherals. The increasing reliability of microprocessors and memory have been referred to several times together with the lack of requirement for a carefully controlled operating environment. Whilst this is true for the electronic components that make up the CPU or memory, it is often not so true for the peripherals, nor for the links between peripherals. Floppy disk drives are particularly sensitive to heat, smoke and static electricity. It is often necessary to run a system in an office environment with additional cooling fans. These problems may become more serious in places with very warm, cold or humid climates.

d. Interfacing with other systems

Communications interfaces are not yet a standard feature on all microcomputers. The standard RS-232 C (V 24) interface is usually available as an additional option (a plug-in unit) and allows simple interaction with remote computers, such as on-line interrogation and retrieval from databases, but does not allow file level manipulation and more complex interaction. If interfacing with another machine is anticipated, then the communications facilities should be thoroughly investigated.

Transfer of information from one system to another e.g., on floppy disk, can cause problems if read/write formats are not compatible. If the application requires an exchange of information in machine-readable form, then compatibility is an important selection criterion.

e. Upgrading

Many applications start off fairly small and grow over time. In these cases the upgrading capability of systems is important. There are two basic upgrade paths that can be followed. One involves moving to the next available size of the same model, which can be accomplished by adding more memory, or more peripherals, or more communications ports etc., or by moving through a product line of a particular manufacturer. The second alternative is to acquire more of the same model. In either case, if growth is anticipated, care must be taken to select the initial system configuration appropriate for the expected growth rate. Some of the very small microcomputers have no upgrade capability at all.

f. Servicing

Most machines require servicing and maintenance at some time during their lifespans and computers are no exception. Many microcomputers are sold to the public through third-party vendors reather than directly by the manufacturers. Often, maintenance is not performed by the vendor with the result that service times increase due to the intervention of a third-party to transact the business. The developing nations, in particular, may run into serious problems in having equipment maintained and serviced.

g. Software

There has been a recent increase in the availability of "off-the-shelf" software, although not much is readily applicable to information handling. The best way to survey what is available is through conferences and exhibitions, especially as the software systems are often demonstrated in that environment.

h. Training

The small-scale computer manufacturers, because they often retail through a third-party vendor, do not, on the whole, offer standard training courses. Instead training is often accomplished through the use of a special software module plus its documentation which "walks the user through" the system features.

The growth in the availability of low-cost microcomputers has seen an accompanying growth in the numbers of informal user groups who meet to exchange ideas and experiences. These relate to all aspects of the system - hardware, software, operations, training. Involvement in such a group would supplement any information and ideas found in the literature.

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ANALOG : The representation of numerical quantities by means of physical variables e.g. translation, rotation, voltage etc.

ASSEMBLER : A computer program that produces MACHINE-CODE from input in the form of source assembly language (the lowest-level programming language, i.e., the one which is closest to machine-code). Also see COMPILER.

BIT : A binary digit, i.e., a digit which can only take on the values of 0 or 1. Bits are the smallest units of information and may be combined into BYTES, WORDS, etc., which, in turn, are used to represent useful data (composed of letters, numerals and special signs).

BYTE : A combination of BITS (usually 4, 6 or 8 bits as well as a parity bit)which represents one character (i.e. a letter, numeral or special sign). In certain computers the byte is the smallest addressable unit of information.

BUS : A circuit over which data are carried from any of several sources to any of several destinations.

CAPACITOR: A device giving capacitance (that property of an electric non-conductor that permits storage of electrical energy),usually consisting of conducting plates or foils.

COMPILER: A computer program which produces assembly language and/or machine instructions from a specific user program written in a high-level language , e.g., FORTRAN compilers convert programs written in FORTRAN into the appropriate machine-code. Also see ASSEMBLER.

DIGITAL: The utilisation of discrete integral numbers (i.e., BITS) represent information which is to be stored,transferred or processed.

HARDWARE: The mechanical, magnetic, electrical and electronic components of a computer.

INTEGRATED CIRCUIT: A complete electronic circuit built into a single piece of semiconductor material.

MACHINE-CODE: The symbols that a computer can recognize in order to perform basic operations.

MICROMETER: One millionth of a metre

MODEM: Modulator-demodulator, a device which converts from a digital signal to a frequency signal so that one can access a computer via a telephone communications link (which is non-digital).

OPERATING SYSTEM: SOFTWARE which functions concurrently with user programs and controls their execution, as well as providing services such as scheduling, debugging ,input/output control, accounting and storage assignment.

PARITY CHECK:	A summation check in which the BITS in a character or word are added and the sum checked against a single, previously computed parity bit.
RESISTOR:	A device that has electrical resistance and that is used in an electric circuit for protection, operation or current control.
REAL-TIME :	The performance of a computation during the actual time that the related physical or intellectual process transpires in order that the results of the computation can be useful in guiding the process.
SEMICONDUCTOR:	A solid material with an electrical conductivity that lies between the high conductivity of metals and the low conductivity of insulators.
SOFTWARE:	The internal programs or routines that specify the operation of a computer.
TRANSISTOR:	An electrical device utilising semiconductor properties to control the flow of currents in a circuit.
WORD:	A combination of BYTES (and consequently BITS) usable as an entity in computer processing. A word is usually 8, 16 or 32 bits in length. For computers in which information is not organized as bytes, the word is the smallest addressable unit of information.

MINICOMPUTER MANUFACTURERS

(A partial listing)

AUSTRIA		
ECO Computer GmbH & Co. K.G.	Wiener Strasse 99, 2513 Traiskirchen.	02252 52791
BELGIUM		
Vector International	Research Park, 3030 Leuven.	016 202496
CANADA		
Katcard Systems Ltd.	Suite 306, 376 Churchill Avenue, Ottawa, Ontario, Canada K1Z 503.	(613) 731-8432
MCM Computers Ltd.	P.O. Box 310, 133 Dalton Street, Kingston, Ontario, Canada K7L 4W2.	(613) 544-9860
Systems Approach, Ltd.	1257 Alzoma Road, Ottawa, Ontario, Canada.	(613) 741-9500
DENMARK		
A/S Regnecentralen	Falkoner Alle 1, 2000 Copenhagen F, Denmark.	(01)10 54-66
RC. Computer A/S	Lautrwpbjerg 1, 2750 Ballerup.	02 658000

FRANCE

Alvan	201 rue de Vaugirard, 75015 Paris.	56755 13
Intertechnique	B.P. 1, 78370 Plaisir.	460 3300
LogAbax S.A.	79 avenue Aristide Briand, 94110 Arcueil.	644 11 30
MBC-Alcyane	Avenue des Trophiques, B.P. 12, 91401 Orsay-Cedex.	907 78 26
Realisations Etdues Electroniques	Zone d'Activities de Courtaboeuf, 91403 Orsay.	(1)907 47 77
Societe d'Informatique Moderne et de Gestion (SIMOG)	91 rue de Faubourg St. Denis, 75010 Paris.	824 48 11
Societe Europeenne de Mini-Informatique et de Systemes (SEMS)	Les Bureax du Parc, B.P. 4, rue de la Princesse, 78430 Louveciennes.	958 39 50
Informetek	Avenue du Parana, AZ de Courtaboeuf, BP 81, Les Ulis, 91401 Orsay.	907 6618

FEDERAL REPUBLIC OF GERMANY

Adcomp Datensysteme GmbH	Horemannstrasse 8, 8000 Munich 19.	(089) 19 40 19
AEG-Telefunken AG	Theodor-Stern-Kai 1, D-6000 Frankfort 70.	(0611)600 31 88
Computertechnik Muller (CTM)	Max Stromeyer Strasse 37, 7750 Konstanz.	(0731)6 30 11
David Datentechnik GmbH (DDC)	Maybachstrasse 42, 7000 Stuttgart 30.	(071181 30 15
Diehl Datensysteme GmbH	Postfach 1129, Bahnhofsplatz 6, 8500 Nuremburg 1.	(0911)21 41
Dietz Computer Systeme	Solinger Strasse 9, D-4330 Mulheim am Ruhr.	(0208)48 50 24
Kienzle Apparate GmbH	Heinrich Hertz Strasse, D-7730 Villingen.	(08821)8 71
Nixdorf Computer AG	Furstenweg, 4790 Paderborn.	(05251)20 01
NM-IDV	Becker Gundahlstrasse 3, 8000 Munich 71.	
Siemens AG	Wittelsbacherplatz 2, 8000 Munich2.	(089) 2341
ATM Computer GmbH	Bucklestrasse 1-5, 7750 Konstanz.	07531 862764
BASF AG	Abteilup Datentcdnik, Gottlieb-Daimter Strasse 10, 6800 Mannheim 1.	0621 40081

ITALY		
Insel S.p.A.	Via Turanense KM 41.500, 67061 Carsoli.	(0863)99105
(Business Machines.)	Via Giuseppe Mussi 5, 00139 Rome.	(06)812 43 41
Honeywell Information Systems	Italia, 32 via Pirelli, 20125 Milan.	02 62571
MALL Computer Sp.A.	via Giuseppe Mussi 5, 00139 Rome.	8126542.
JAPAN		
Fujitisu Ltd.	Marunouchi 2-chome, Chiyoda-ku, Tokyo.	(03)216 3211
THE NETHERLANDS		
Daisy Systems Holland B.V.	Nieuweweg 279, 6600 AC-Wijchen.	08894 8170
Philipe Data Systems B.V.	Postbus 265, 7300 AGA peldoorn.	055 230123
NORWAY		
Norsk Data A.S	Lorenveien 57, P.O. Box 163, Okern, Oslo 5.	(02) 21 73 71
Tandbergs Radiofabrikk A/S	Kjelsaaveien 161, Oslo 8.	(47-2)23 20 80
SWEDEN Datasaab AB	Veddestavagen 13 S-175 62 Jarfalla.	89 00 60
SWITZERLAND		
SEN Electronique S.A.	Avenue Ernest Pictet 31, 1211 Geneva 13.	(022) 44 29 40

UNITED KINGDOM

England

Allied Business Systems Ltd.	1 Berkeley Street, London W1X 6NN.	(01)499-9020
Business Computers (Systems) Ltd.	North Street, Brighton BN4 1ER.	(0273)413211
Computer Ieformation Centre Ltd.	286 Pentonville Road, London N1 9NY.	(01)278-5187
Computer Instrumentation Ltd.	School Lane, Chandler's Ford, Eastleigh, Hants SO5 3YY.	(042)15-66321
Computer Technology Ltd.	Eaton Road, Hemel Hempstead, Hertfordshire HP2 7LB.	(0442)-3272
Digico Ltd.	Wedgewood Way, Stevenage, Hertfordshire SG1 4PY.	(0438)-4381
Ferranti Ltd.	Hollinwood, Lancashire OL9 7JS.	(061)681-2000
GEC Computers Ltd.	Elstree Way, Borehamwood, Hertfordshire WD6 1RX.	(01)953-2030
Plessy Components Ltd.	Water Lane, Towcester, Northants NN12 7JG.	(0327) 50312
Redifon Computers Ltd.	Kelvin Way, Crawley, Sussex RH10 2PP.	(0293) 31211
Solitaire Business Systems	28 The Butts, Brentford, Middlesex.	(01)568-7345
Systime Ltd.	Concourse Computer Centre, 432 Dewsbury Road, Leeds LS11 7DF.	(0532) 707411
Transdata Ltd.	11 Garrick Street, London WC2.	(01)240-2713
(Business machines)	36 Solent Road, Havant, Hants.	(070 12) 6556

Scotland

Dacoll Engineering Services Ltd.	Dacoll House, Gardeners Lane, Bathgate, West Lothian.	(0506) 56565

U.S.A.

Advanced Information Design,	1240 Elko Drive, Sunnyvale, California 94022.	(408) 744-0900
A.K. Industries	P.O. Box 286, Skippack, Pennsylvania 19474.	(215) 659-2510
Anderson-Jacobsen, Inc.	521 Charcot Avenue, San Jose, California 95131.	(408) 263-8520
Applied Data Communications	1509 East McFadden, Santa Ana, California 92705.	(714) 547-6954
Applied Data Processing, Inc.	33 Bernhard Road, North Haven, Connecticut 06473.	(203) 787-4107
Applied Digital Communications	214 West Main Street, Moorestown, New Jersey 08057.	(609) 234-3666
Applied Systems Corp.	26401 Harper Avenue, St. Clair Shores, Michigan 48081.	(313) 779-8700
J. Baker & Associates	5135 West Golf Road, Skokie, Illinois 60076.	(312) 677-9760
Basic/Four Corporation	14101 Myford St. Road, Tustin, California 92680.	(714) 731-5100
Binary Data Systems, Inc.	88 Sunnyside Boulevard, Plainview, New York 18803.	(516) 822-1585
BRD (bainbridge Research & Development), Inc.	12715A Millar Road, N.E. Bainbridge Island Washington 98110	(206) 842-4777
BTI Computer Systems	870 West Maude Avenue, Sunnyvale, California 94086.	(408) 733-1122

U.S.A. continued

(Business machines)	650 North Mary Avenue, Sunnyvale, California 94086	
Burroughs Corporation	Burroughs Place, Detroit, Michigan 48232.	(313) 972-7000
Business Controls Corporation	507 Boulevard, Elmwood Park, New Jersey 07407.	(201) 791-7661
Business Systems Products, Inc.	16782 Red Hill Avenue, Irvine, California 92714	(714) 957-1851
Cado Systems Corporation	2771 Toledo Drive, Torrance, California 90503.	(213) 320-9660
(Business machines)	2730 Monterey Street, Torrance, California 90503.	
Cascade Data, Inc.	6300 28th Street, S.E., Grand Rapids, Michigan 49506.	(616) 942-1420
CDA (Computer Data Access), Inc.	1373 Broad Street, Clinton, New Jersey 07011	(201) 473-4700
(Business machines)	470 Commercial Avenue, Palisades Park, New Jersey 07650.	(201) 944-2500
Century Computer Corporation	2339 Stanwell Circle, Concord, California 94520.	(415) 798-8000
(Business machines)	1601 North Main Street, Walnut Creek, California 94596.	
Cincinnati Milacron	Electronic Systems Div., Mason/Marrow Road, Lebanon, Ohio 45036.	(513) 494-1200

U.S.A. continued

Compal Computer Systems	6300 Variel Avenue, Suite E, Woodland Hills, California 91367.	(213) 992-4425
Complete Computer Systems	159 Gibraltar Road, Prudential Business Campus, Horsham, Pennsylvania 19044.	(215) 441-4200
Compucorp	1901 South Bundy Drive, Los Angeles, California 90025.	(213) 820-2503
Compudata Systems, Inc.	772 Post Road East, (East State Street.), Westport, Connecticut 06880.	(203) 226-4791
Computer Automation, Inc.	18651 Von Karmen Avenue, Irvine, California 92664.	(714) 833-8830
Computer Covenant Corporation	749 Farmington Avenue, Farmington, Connecticut 06032.	(203) 667-6563
Computer Design Systems, Inc.	8085 Wayzata Boulevard, Minneapolis, Minnesota 55426.	(612) 545-2855
Computer Hardware, Inc.	4111 North Freeway Blvd., Sacramento, California 95834.	(916) 929-2020
Computer Horizons Corporation	375 Sylvan Avenue, Englewood Cliffs, New Jersey 07632.	(212) 371-9600
Computer Interactions, Inc.	P.O. Box 1354, Roslyn Heights, New York 11577.	(516) 365-9833
Computer Talk Inc.	P.O. Box 100, Idledale, Colorado 80453.	(303) 697-5485
Computervision Corporation	201 Burlington Road, Route 62, Bedford, Massachusetts 01730.	(617) 275-1800

U.S.A. continued

Control Data Corporation	4400 Computer Drive, Westboro, Massachusetts 01581.	(617) 366-8911
(Business machines)	P.O. Box O, Minneapolis, Minnesota 55440.	(616) 853-4656
Corstar Business Computing Co., Inc.	One Aqueduct Road, White Plains, New York 10606.	(914) 428-5550
Data Communications Corp.	Minicomputer Division, 3000 Directors Row, Memphis, Tennessee 38131.	(901) 345-3544
Data General Corporation	Route 9, Southboro, Massachusetts 01581.	(617) 366-8911
Datapoint Corporation	9725 Datapoint Drive, San Antonio, Texas 78229.	(512) 690-7000
Dataram Corporation	Princeton-Hightstown Rd., Cranbury, New Jersey 08512.	(609) 799-0071
Decision Data Computer Corporation	100 Witmer Road, Horsham, Pennsylvania 19044.	(215) 674-3300
Diablo Systems Inc.	1270 East Arques Ave., Sunnyvale, California 94086.	(408) 733-2300
Digital Computer Controls Inc.	12 Industrial Road, Fairfield, New Jersey 07006	(201) 575-9100
Digital Equipment Corporation	129 Parker Street, Maynard, Massachusetts 01754.	(617) 897-5111
Digital Scientific Corporation	11455 Sorrento Valley Rd., San Diego, California 92121.	(714) 453-6050

U.S.A. continued

Digital Systems Corporation	P.O. Box 396, Walkersville, Maryland 21793.	(301) 845-4141
Dimis, Inc.	1060 Highway 35, Middletown, New Jersey 07748.	(201) 671-1011
Display Data Corporation	Executive Plaza IV, Hunt Valley, Maryland 21031.	(301) 667-9211
Distribution Management Systems, Inc.	11 DeAngelo Drive, Bedford, Massachusetts 01730.	(617) 275-2000
Durange Systems, Inc.	3003 North First Street, San Jose, California 95134.	(408) 946-5000
Financial Computer Corporation	412 West Redwood Street, Baltimore, Maryland 21201.	(301) 837-9510
Four-Phase Systems, Inc.	10700 North DeAnza Blvd., Cupertino, California 95014.	(408) 255-0900
(Business machines)	19333 Vallco Parkway, Cupertino, California 95014.	
Functional Automation, Inc.	3 Graham Drive, Nashua, New Hampshire 03060.	(603) 888-1905
General Information Systems, Inc.	P.O. Box 17388, Irvine, California 92713.	(714)834-0220
General Robotics Corporation	55-57 North Main St., Hartford, Wisconsin 53027.	(414) 673-6800
GRI Computer Corporation	320 Needham Street, Newton, Massachusetts 02164.	(617) 969-0800

U.S.A. continued

Harris Corporation	Computer Systems Div., 2101 West Cypress Creek Rd., Fort Lauderdale, Florida 33309.	(305) 974-1700
(Business machines)	1200 Gateway Drive, Fort Lauderdale, Florida 33309.	
Hewlett-Packard	GSD Division, 19447 Prunridge Ave., Cupertino, California 95014.	(408) 725-8111
(Business machines)	GSD Division, 5303 Stevens Creek Road, Santa Clara, California 95050.	(408) 249-7020
(Data Systems Division)	11000 Wolfe Road, Cupertino, California 95014.	(408) 257-7000
(Desktop Computer Division.)	P.O. Box 1550, Fort Collins, Colorado 80522.	(303) 226-3800
Honeywell Information Systems, Inc.	200 Smith Street, Waltham, Massachusetts 02154.	(617) 890-8400
(Small/Medium Information Systems Division)	300 Concord Road, Billerica, Massachusetts 08121.	(617) 667-3111)
IBM Corporation	General Systems Div., P.O. Box 2150, Atlanta, Georgia 30301.	(404) 256-7000
ICL, Inc.	Turnpike Plaza, 197 Highway 18, 3rd Floor, East Brunswick, New Jersey 08816.	(201) 246-3400
Infotecs Computer Systesm	One Perimeter Road, Manchester, New Hampshire 03103.	(603) 668-6750

U.S.A. continued

Jacquard Systems	1639 11th Street, Santa Monica, California 90404.	(201) 575-8100
Keydata Corporation	20 William Street, Wellesley, Massachusetts 02181.	(617) 237-6930
Litton Industries, Inc.	Sweda International Div., 34 Maple Avenue, Pine Brook, New Jersey 07058.	(201) 575-8100
Lockheed Electronics Co. Inc.	Data Technology Div., U.S. Highway 22, Plainfield, New Jersey 07061.	(201) 757-1600
Logical Machine Corporation	1294 Hammerwood Avenue, Sunnyvale, California 94086.	(408) 744-1290
Melcom Business Systems, Inc.	2200 West Artesia Blvd., Suite 101, Compton, California 90220.	(213) 979-6055
Microdata Corporation	17481 Red Hill Avenue, Irvine, California 92705.	(714) 540-8341
Mini-Computer Systems, Inc.	525 Executive Boulevard, Elmsford, New York 10523.	(914) 592-8812
Minuteman Computer Corporation	230 Second Avenue, Waltham, Massachusetts 02154.	(617) 890-4070
Modular Computer Systems, Inc.	1650 West McNab Road, Fort Lauderdale, Florida 33310.	(305) 974-1380
Mylee Digital Sciences, Inc.	155 Weldon Parkway, Maryland Heights, Missouri 63043.	(314) 567-3420

U.S.A. continued

Nanodata Corporation	1 Computer Park, Buffalo, New York 14203.	(716) 631-6000
NCR Corporation	Main and K Streets, Dayton, Ohio 45479	(513) 449-2000
New England Digital Corporation	Main Street, Norwich, Vermont 05055.	(802) 649-5183
Nixdorf Computer Inc.	168 Middlesex Turnpike, Burlington, Massachusetts 01803.	(617) 273-0480
Northern Telecom Systems Corp.	P.O. Box 1222, Minneapolis, Minnesota 55440.	(612) 932-8000
Northrop Data Systems	1160 Sandhill Avenue, Carson, California 90746.	(213) 637-1533
(Business machines)	19000 South Vermont Ave., Torrance, California 90502	(213) 637-1533
Olivetti Corporation of America	500 Park Avenue, New York 10022.	(212) 371-5500
Perkin Elmer Computer Systems Div.	2 Crescent Place, Oceanport, New Jersey 07757.	(201) 229-6800
Philips Business Systems, Inc.	175 Froelich Farm Blvd., Woodbury, New York 11797.	(516) 921-9310
Point 4 Computer Corporation	2659 McCabe Way, Irvine, California 92714.	(714) 556-4242
Prime Computer, Inc.	40 Walnut Street, Wellesley Hills, Massachusetts 02181.	(617) 237-6990
Programmed Control Corporation	2 East Broad Street, Hopewell, New Jersey 08525.	(609) 466-2100

U.S.A. continued

Ql Corporation	6 Dubon Court, Farmingdale, New York 11735.	(516) 543-7800
Quantel Corporation	3525 Breakwater Avenue, Hayward, California 94545.	(415) 783-3410
Quodata Corporation	196 Trumbull Street, Hartford, Connecticut 06103.	(203) 728-6777
Randal Data Systems, Inc.	365 Maple Avenue, Torrance, California 90503.	(213) 320-8550
Raytheon Data Systems Company	1415 Boston-Providence Turnpike, Norwood, Massachusetts 02062.	(617) 762-6700
Rolm Corporation	4900 Old Ironsides Dr., Santa Clara, California 95050.	(408) 988-2900
Span Management Systems	1 Catamore Boulevard, East Providence, Rhode Island 02914.	(401) 438-2200
Sperry Univac Division (Sperry Rand Corp.)	P.O. Box 500, Blue Bell, Pennsylvania 19424.	(215) 542-4011
Sperry Univac Minicomputer Operations	P.O. Box C-19504, 2722 Michelson Drive, Irvine, California 92713.	(714) 833-2400
STC, Inc.	9 Brook Avenue, Marywood, New Jersey 07607.	(201) 845-0500
STC Systems, Inc.	E-210 Route 4, Paramus, New Jersey 07652.	(201) 843-0560
Sycor, Inc.	100 Phoenix Drive, Ann Arbor, Michigan 48104.	(313) 995-8527

U.S.A. continued

Systems Engineering Laboratories, Inc.	6901 West Sunrise Blvd., Fort Lauderdale, Florida 33313.	(305) 587-2900
Tal-Star Computer Systems, Inc.	P.O. Box T-100, Princeton Junction, New Jersey (08550).	(609) 799-1111
Tandem Computers, Inc.	19333 Vallco Parkway, Cupertino, California 95014.	(408) 996-6000
Terak Corporation	14405 North Scottsdale Rd., Suite 100, Scottsdale, Arizona 85260.	(602) 991-1580
Texas Instruments, Inc.	P.O. Box 2909, Austin, Texas 78769.	(512) 250-7309
Wang Laboratories, Inc.	836 North Street, Tewksbury, Massachusetts 08176.	(617) 851-4111
Warrex Computer Corporation	1780 Jay Ell Drive, Richardson, Texas 75081.	(214) 699-8400
(Business machines)	12505 North Central Expressway, Dallas, Texas 75243.	(214) 233-8400
Xerox Corp.	440 Oakmead Parkway, Sunnyvale, California 94086.	(408) 733-2300

ANNEX III

MICROCOMPUTER SYSTEMS
(A partial listing)

Manufacturer	Max. Memory (bytes)	Prices from:[1)]
Acorn Computers	1K	£75
Apple Computers	48K	£1,000
Attache	64K	£1,737
Brutech Electronics	ROM only	£133
Comart		£255
Commodore Systems Division		
i. Pet		£460
ii. Kim-1	1K	£100
Compelec Electronics	64K	under £5,000
Compucolor	32K	£1,390
Compucorp	60K	£3,890
Computer Centre	16K	£786
Computer Workshop		
i. System 1	40K	£5,000
ii. System 2	24K	£3,000
iii. System 3	12K	£1,300
Cromemco		
i. Single-card computer	1K	£247
ii. Z-2	512K	£372
iii. System Two	512K	£2,294
iv. System Two/64	64K	£3,050
v. System Three	512K	£3,444
vi. System Three/64	512K	£4,385

1) These approximate prices in mid-1980 in pounds sterling are intended only to be indicative. In June 1981 £1 = US$2.31.

Equinox	256K	£5,000
Exidy	32K	£760
Hewart Microelectronics		
i. Mini 6800 Mk II	1K	£128
ii. 6800S	16K	£275
Digital Microsystems	64K	£4,465
Imsai	64K	£4,507
ITT	48K	£827
Luxor	40K	£795
Micronics	2K	£400
Micro V	64K	£4,950
Midwest Scientific Instruments	32K	£815
Nascom Microcomputers	64K	£165
National Multiplex	48K	£2,700
Netronics	64K	£80
Newbear	64K	£45
North Star	56K	£995
Ohio Scientific		
i. Ohio Superboard II	4K	£298
ii. Challenger C24P	4K	£343
iii. Challenger C28P	4K	£435
iv. Challenger C3	768K	£2,450
Pertec	64K	£3,000
Processor Technology	16K	£1,750
Rair	64K	£2,300

Research Machines		
i. 380-Z	56K	£830
ii. 280-Z	32K	£398
RCA		£80
Rockwell	4K	£250
Scientific of Cambridge	½K	£40
SDS	46K	£3,750
Semel	64K	£1,950
Sord		
i. M100	48K	£726
ii. M222	64K	£3,450
iii. M223	64K	£3,775
Synertek	64K	£200
Tandy Corp.	48K	£500
Transam Components	65K	£286
Vector Graphic	63K	£2,300

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